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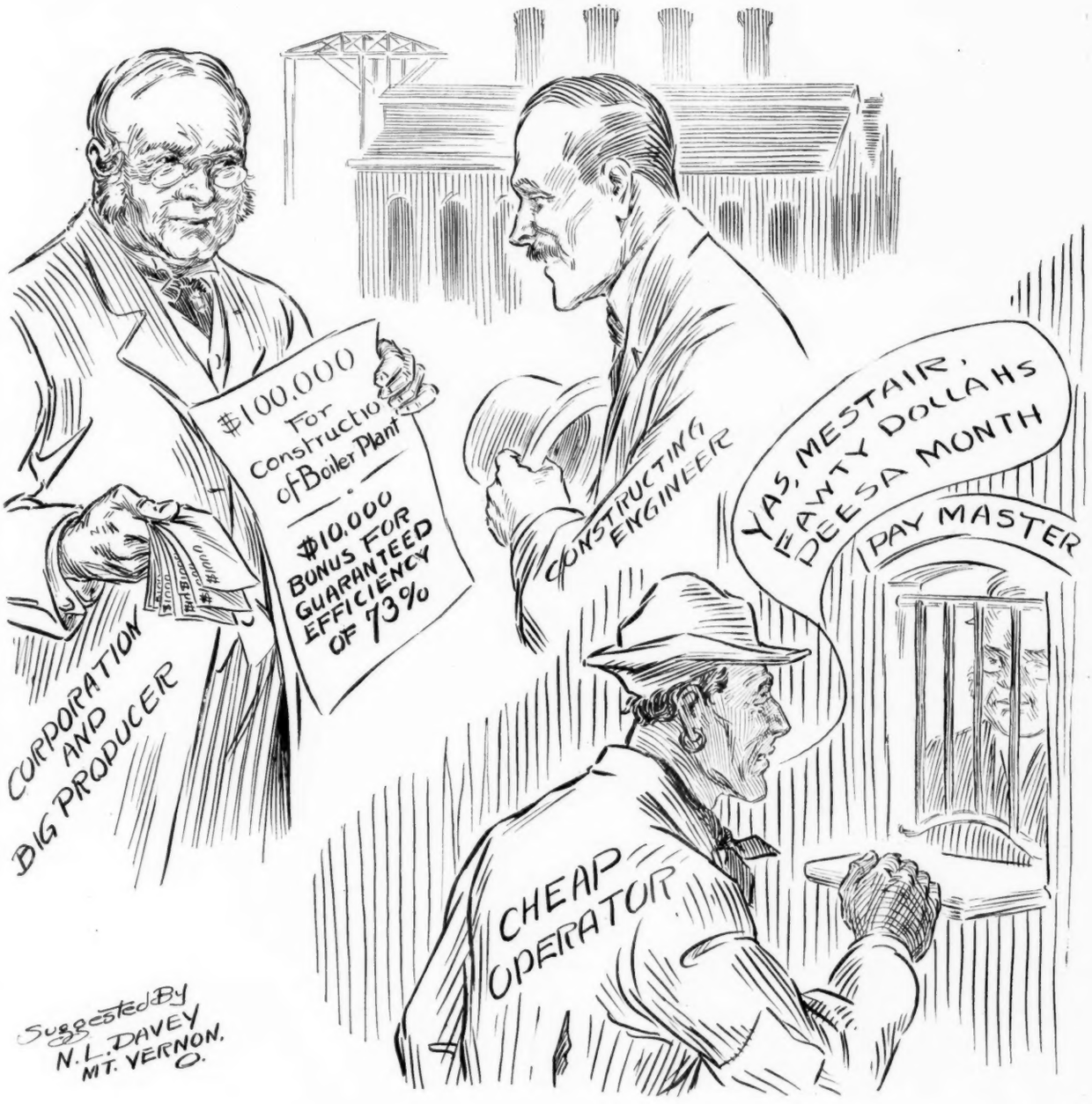
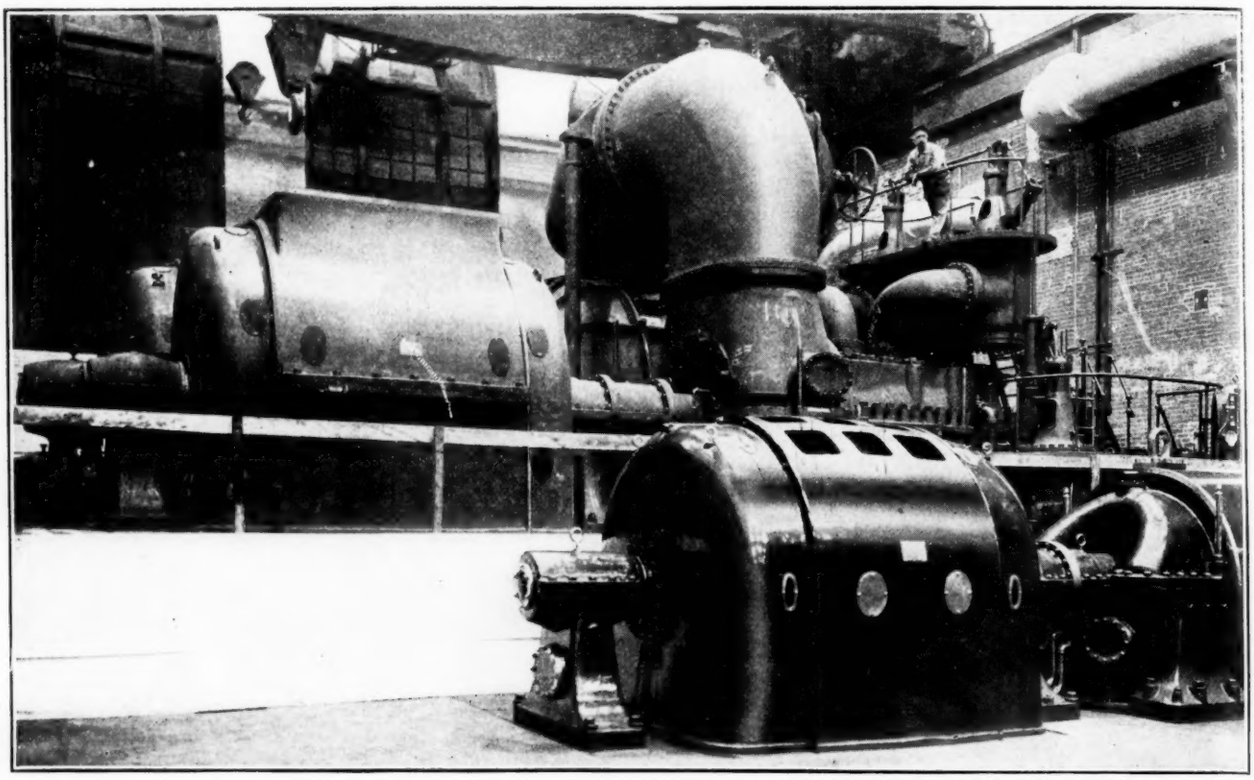

$100,000 For Construction of Boiler Plant
$10,000 BONUS FOR GUARANTEED EFFICIENCY OF 73%
CONSTRUCTING ENGINEER
YAS, MESTAIR, LAWNTY DOLLAHS DEE SA MONTH
PAY MASTER
CORPORATION AND BIG PRODUCER
CHEAP OPERATOR
Suggested By N. L. DAVEY MT. VERNON, O.

Now Don't Be Foolish

After employing the best consulting and constructing engineers to build a power plant costing thousands of dollars and containing the best up-to-date machinery, do not stop there and in a fit of economy engage cheap, incompetent engineers and firemen to run it. The common laborer was all right for the rough work, but burning coal efficiently requires brains and skill. Operating a power plant demands experience and intelligence. Few men would be trusted with $100,000 in cash without security. Why intrust that amount of money invested in power-plant apparatus to an incompetent because he can be obtained at a low wage? One usually gets what he pays for, and no more.



The Forty-Five-Thousand Kilowatt Compound Turbine at Providence, R. I.

By J. P. RIGSBY*

An unusually well-illustrated description of the 45,000-kw. cross-compound reaction Westinghouse turbine recently started at the South Street Station of the Narragansett Electric Lighting Company, Providence, R. I.

THE 45,000-kw. turbo-generator unit recently put in operation in the power station of the Narragansett Electric Lighting Co., Providence, R. I., is of the Westinghouse cross-compound double-unit type, consisting of a high- and a low-pressure turbine, each connected through a flexible coupling to its own generator, having a capacity of 22,500 kw., and mounted on separate bedplates supported on foundations lying parallel to each other. The generators are arranged to feed separately or together to the main bus. This turbine is shown at top of this page.

This multiple-cylinder type of turbine is exemplified by the three 30,000-kw. units installed a few years ago in the Seventy-fourth Street Station of the Interborough Rapid Transit Co., New York City, and described in *Power* of Apr. 20, 1915; test report on, in *Power*, May 23, 1916.

Steam enters the high-pressure turbine, Fig. 1, through suitable governor-controlled valves, passes through this single-flow element and out through an exhaust on the top and is conducted by means of a receiver pipe overhead to the middle of the double-flow low-pressure turbine, Fig. 2, alongside, where it divides, flowing in opposite directions through the low-pressure blading, then down through the exhaust chambers into two Westinghouse-Leblanc jet condensers, Figs. 8 and 9, of the latest type.

The energy given up by the steam at full load is equally divided between the high- and the low-pressure turbines, the generators dividing the load in half; at lower loads a greater proportion is carried by the high-pressure element.

The unit was designed to operate with a steam pressure at the throttle of 200 lb. with 100 deg. F. superheat, and a vacuum of 29 in. in the exhaust, while the generators have a capacity of 23,750 kv.-a., 11,000 volts three-phase 60-cycle at 0.95 power factor, the high-pressure element having a speed of 1800 r.p.m. and the low-pressure 1200.

There are four bearings to each unit, a flexible pin-type coupling being used to connect the turbine and generator.

The high-pressure turbine is of the single-flow reaction type throughout, of a simple, rugged construction, all parts coming in contact with high pressure steam, being made of cast steel, while the exhaust chamber and other parts not subjected to high temperature or to high stresses are of cast iron. The pressure in the

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high-pressure cylinder varies from a maximum of about 200 lb. at the inlet to atmospheric pressure in the receiver pipe at full load.

With the reaction-type machine, high-pressure steam is admitted, of course, direct to the cylinder casing instead of into nozzle chambers, as is the case with an impulse type. This presents the problem of perfecting a horizontal joint on a cylinder of considerable diameter that will be tight and stay tight, against 200 to 300 lb. steam pressure, or any tendency to open, due to distortions from the high temperature.

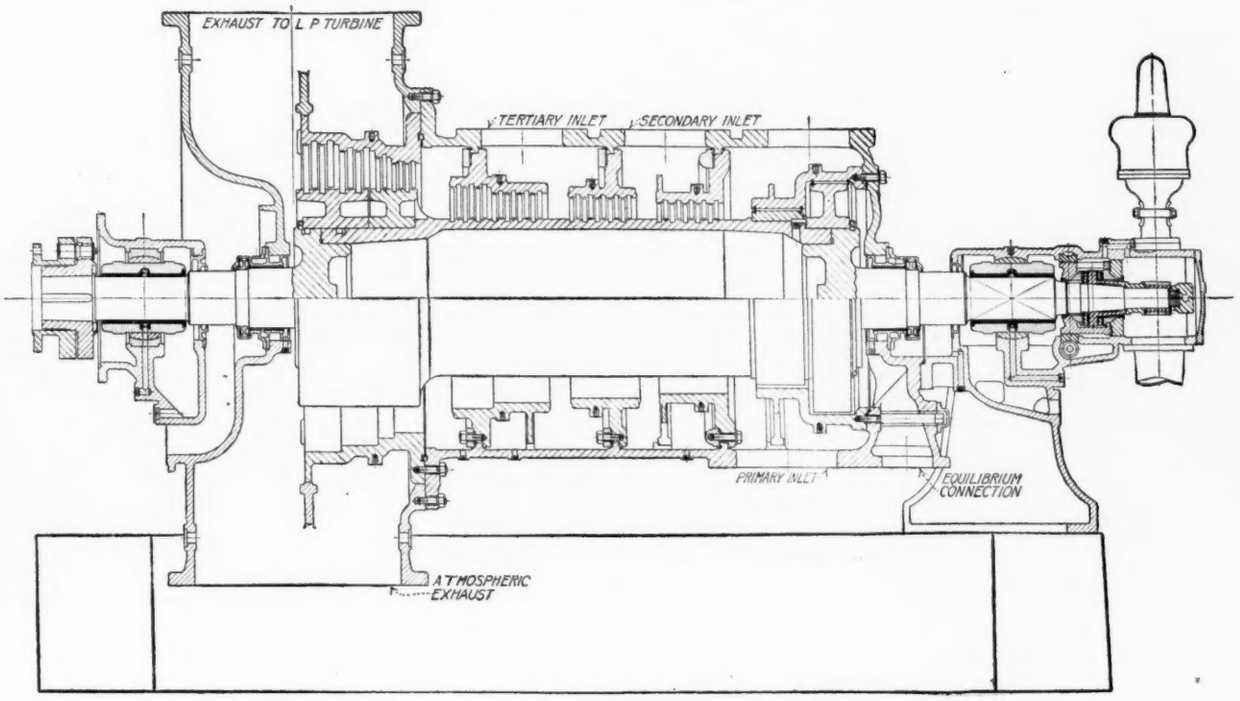


FIG. 1. SECTION OF HIGH-PRESSURE TURBINE; NOTE THE STEAM INLETS

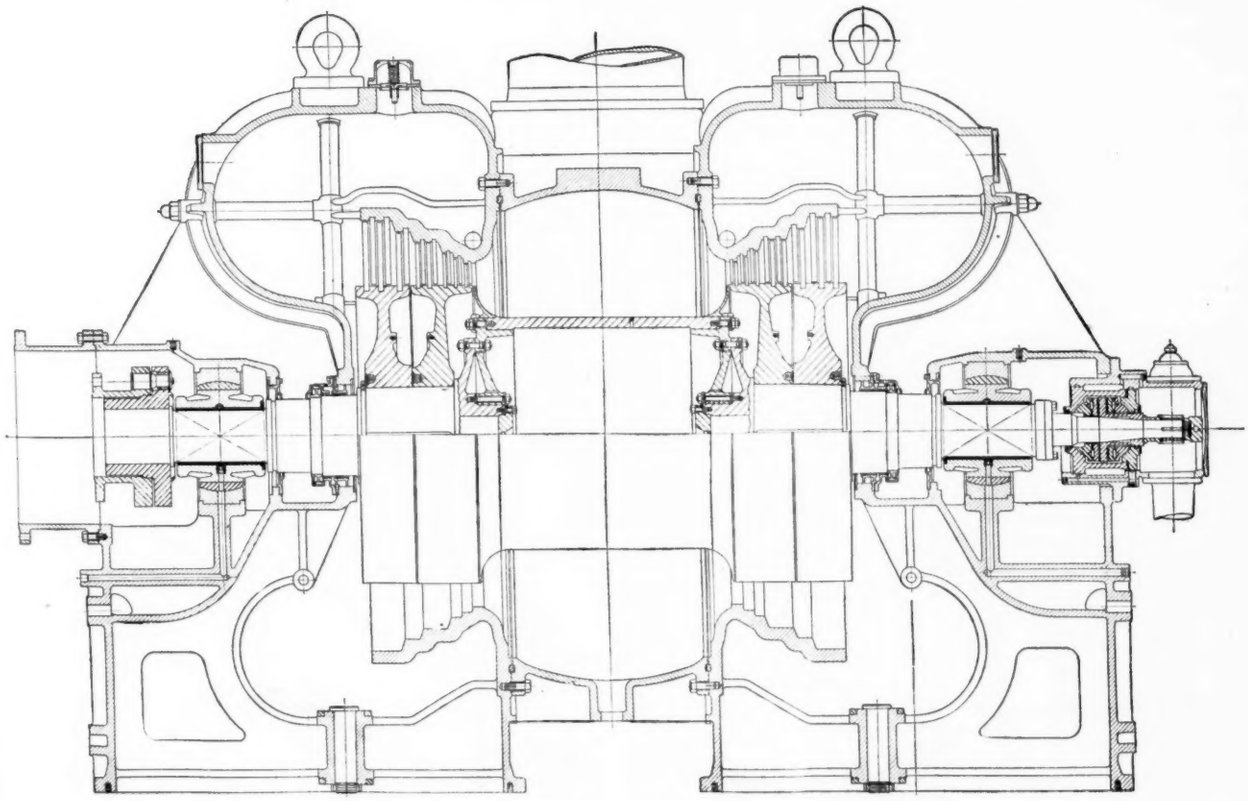


FIG. 2. SECTION OF LOW-PRESSURE DOUBLE-FLOW TURBINE

The high-pressure end, or steel part of the cylinder, is composed of two steel castings, 5 ft. 10 in. inside diameter and 1¾ in. thick, while at the joint the thick-

ness gradually increases until it merges into a flange 8 in. wide, tapering to the outer edge. Bolts 2¼ in. in diameter are spaced about one-third of the way from the inside edge, and 4 in. between centers. These bolts or studs, as they really are, are tapped alternately into upper and lower flanges registering with suitable bosses on the companion flange. This method permits of a closer spacing of bolts, removes less metal and produces a stronger flange than by any other means. No gasket is used, the joint being scraped to a surface.

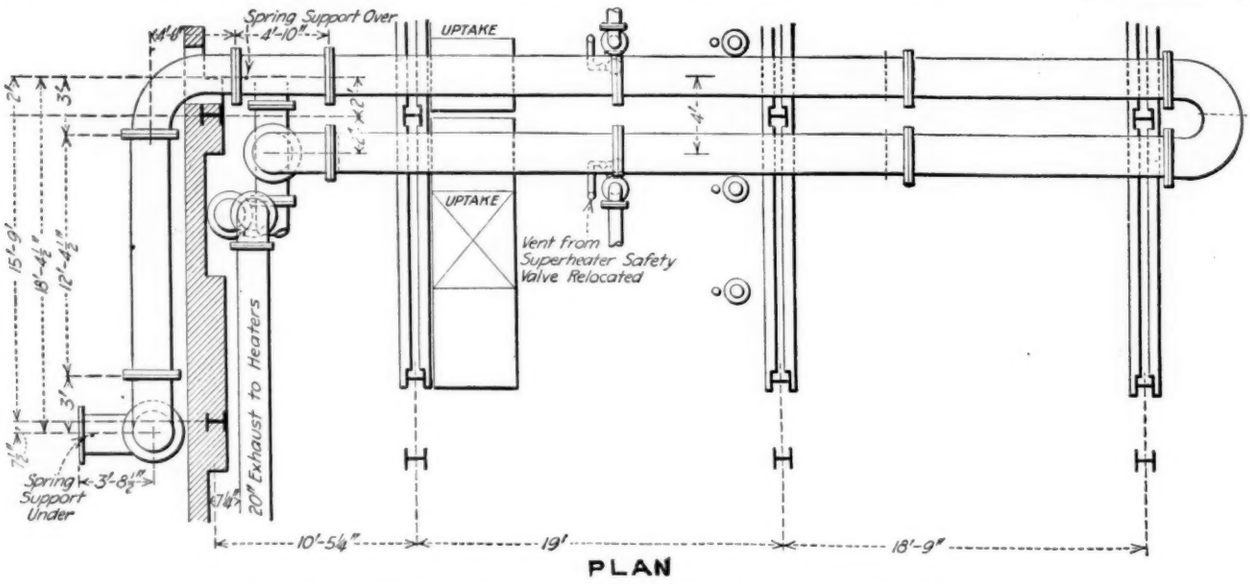


FIG. 3. PLAN VIEW OF STEAM MAIN FROM BOILER ROOM TO THE TURBINE

The four rings containing the blades are not an integral part of the main cylinder, but are made of separate castings jointed in the middle, resulting in simplicity of construction, freedom from strains, and the absence of those difficulties so frequently found in a complicated steel casting, besides being a distinct aid in manufacturing, as the machine work is not all done on one piece, but can be divided among different machines, and finally assembled when each piece is completed. These rings are clamped in place, again saving expensive work on the main castings.

The high-pressure cylinder is supported on three points, as usual, one under the governor, or thrust end, and one on each side of the exhaust, near the center line, thus insuring against distortions, or a possibility of misalignment, due to differential expansions between the turbine and generator supports from unequal temperatures.

The high-pressure spindle consists of a hollow steel drum about three feet in diameter, carrying most of the blading, there being two blade rings of larger diameter on the one end, and corresponding dummy rings, or balance pistons, on the other. The spindle ends are pressed into the drum and are secured with tee-headed shrink links, which are themselves held in place by the blade and dummy rings.

The stresses in the spindle parts are quite low, these parts being made from ordinary carbon steel. However, care is taken in making the castings to insure homogeneity, the precautions necessary to secure this uniformity having been learned by long experience.

There are 24 rows of blades in the high-pressure turbine, ranging in size from 1-in. blades 4 in. long, to 1¼-in. blades 9½ in. long. These blades are unusually strong and rigid, and they insure efficiency and durability. The maximum mean blade speed is 470 ft. per second.

The steam passes out through an exhaust at the top of the cylinder into a 66-in. receiver pipe leading over to the low-pressure turbine. A similar exhaust is provided directly below, which connects through an automatic relief valve to the atmosphere.

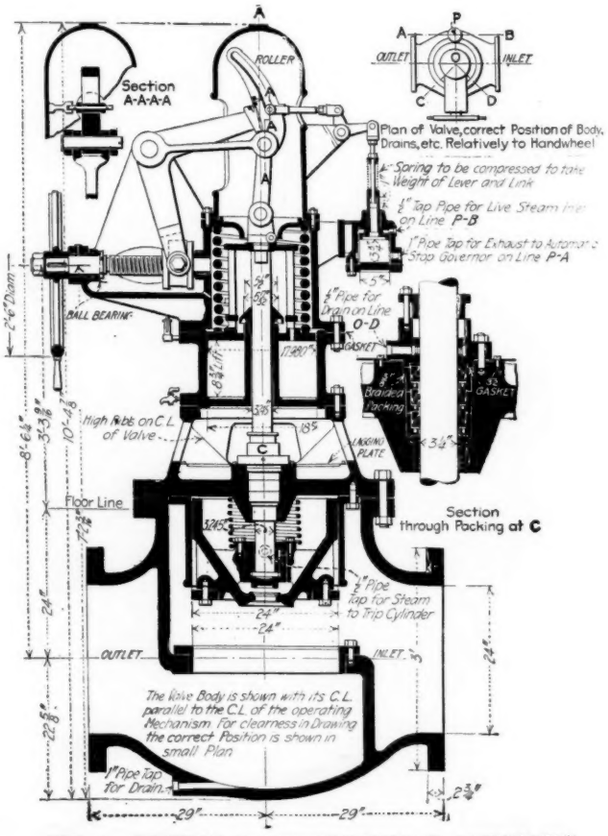

Section A-A-A-A
ROLLER
OUTLET
INLET
Plan of Valve, correct Position of Body, Drains, etc. Relatively to Handwheel
Spring to be compressed to take Weight of Lever and Link
Pipe Tap for Live Steam Inlet on Line P-B
Pipe Tap for Exhaust to Automatic Stop Governor on Line P-A
Pipe for Drain on Line O-D
BALL BEARING
GASKET
Braided Packing
GASKET
High Rib on C.L. of Valve
PACKING PLATE
Floor Line
Section through Packing at C
Pipe Tap for Steam to Trip Cylinder
OUTLET
INLET
The Valve Body is shown with its C.L. parallel to the C.L. of the operating Mechanism. For clearness in Drawing the correct Position is shown in small Plan
Pipe Tap for Drain
29"
29"

FIG. 4. SECTION OF WESTINGHOUSE AUTOMATIC THROTTLE VALVE

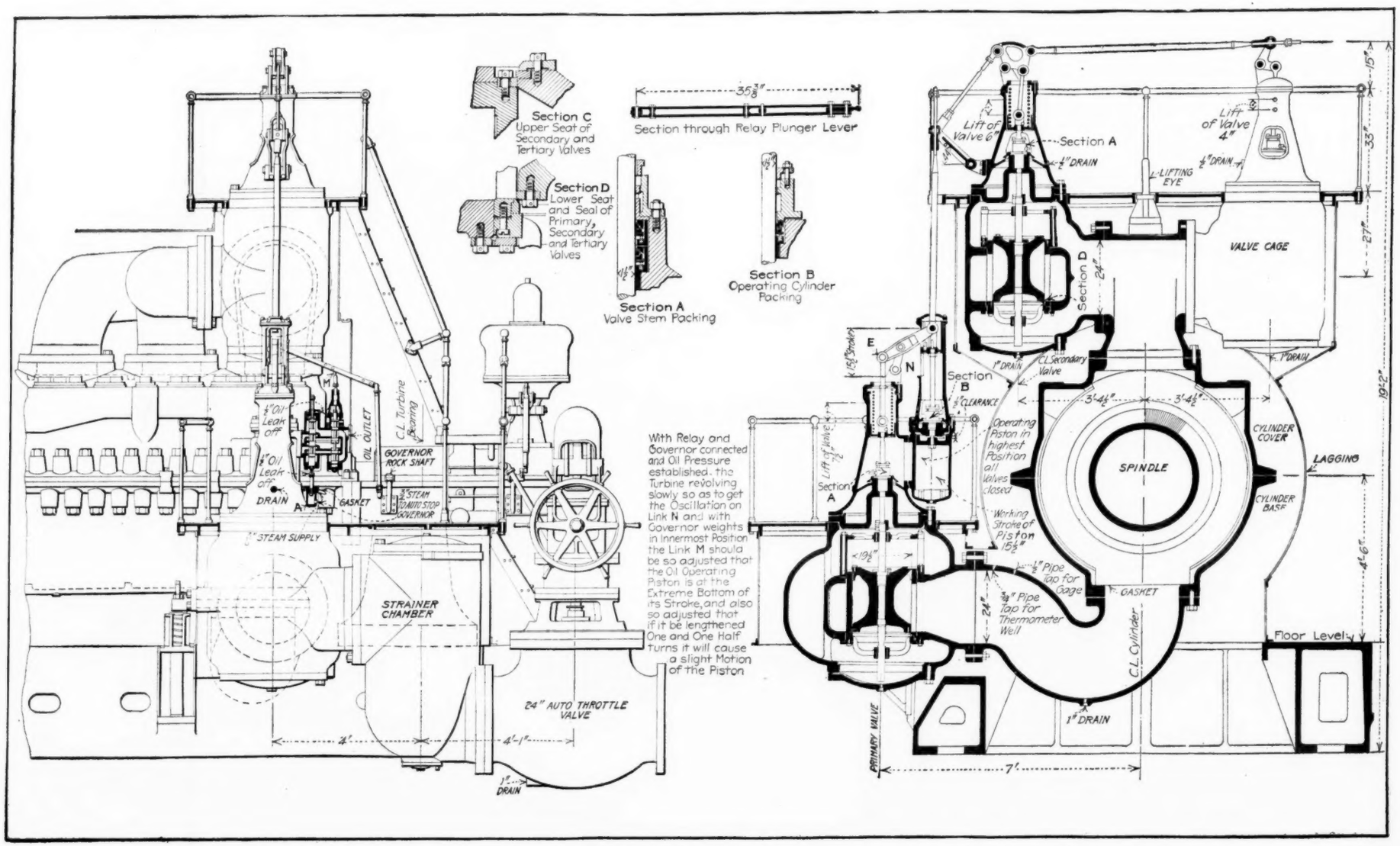

Section C
Upper Seat of Secondary and Tertiary Valves
Section D
Lower Seat and Seal of Primary, Secondary and Tertiary Valves
Section A
Valve Stem Packing
Section through Relay Plunger Lever
Section B
Operating Cylinder Packing
With Relay and Governor connected and Oil Pressure established, the Turbine revolving slowly so as to get the Oscillation on Link N and with Governor weights in Innermost Position the Link M should be so adjusted that the Oil Operating Piston is at the Extreme Bottom of its Stroke, and also so adjusted that if it be lengthened One and One Half Turns it will cause a slight Motion of the Piston
Lift of Valve 6"
Lift of Valve 4"
Section A
LIFTING EYE
VALVE CAGE
Section D
Section B
CL Secondary Valve
CLEARANCE
Operating Piston in highest Position all Valves closed
Working Stroke of Piston 15½"
SPINDLE
CYLINDER COVER
LAGGING
CYLINDER BASE
Floor Level
GASKET
CL Cylinder
PRIMARY VALVE
OIL OUTLET
CL Turbine Bearing
GOVERNOR ROCK SHAFT
GASKET
STEAM SUPPLY
STRAINER CHAMBER
24" AUTO THROTTLE VALVE
DRAIN

FIG. 5. SHOWING THE GOVERNOR MECHANISM OF THE 45,000-KW. WESTINGHOUSE COMPOUND TURBINE AT PROVIDENCE, R. I.

A motor-operated 60-in. gate valve is placed in the receiver pipe, in case it is necessary to operate either turbine alone, the high-pressure turbine running non-condensing under control of its own governor, or the low-pressure turbine on steam admitted through a 14-in. throttle from the high-pressure line, it being connected in step electrically with some other unit in the system.

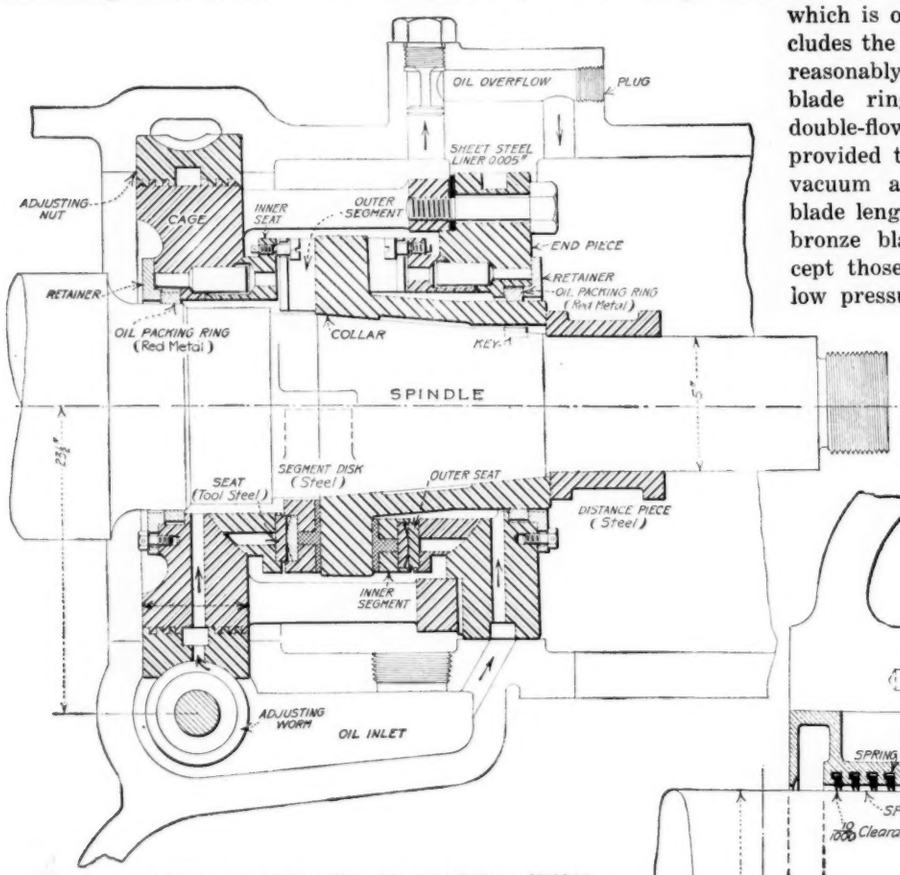


FIG. 6. SECTION OF THE THRUST BEARING—KINGSBURY TYPE

Steam is supplied to the turbine through a 24-in. header, Fig. 3, every care being taken to provide adequate flexibility to the line. A standard Westinghouse-type throttle valve, Fig. 4, with the regular automatic stop features controls the admission. The throttle valve, steam strainer and primary steam chest, which are located adjacent to the bedplate alongside the turbine, are spring-supported, so as not to impose a dead load on the cylinder.

The low-pressure element is of the straight double-flow reaction type. The steam entering at the top through the aforementioned receiver pipe, passes around the spindle in a large annular chamber and enters the low-pressure blading, there being eight rows in each end, ranging from ⅜-in. blades 6 in. long, to 1¼-in. blades 18 in. long.

The low-pressure cylinder rests on four supports applied near the center line on each side of the exhaust chambers. It is free to expand axially, sliding on these supports, the turbine being anchored to the inboard generator pedestal. A system of radial and axial stays in the exhaust chamber produces extreme rigidity, minimizing the possibility of distortion and sympathetic vibrations.

The low-pressure spindle is composed of a central hollow drum, rigidly secured to the spindle ends. Upon each of these ends are mounted two disks carrying the low-pressure blades, the maximum mean velocity of which is only 515 ft. per sec., which precludes the necessity of using other than a reasonably good grade of cast steel in the blade rings. However, owing to the double-flow feature, ample blade area is provided to make the best use of a high vacuum and still maintain conservative blade length in the last rows. Phosphor-bronze blades are used throughout, except those of the last three rows in the low pressure, which are of forged steel.

The low-pressure cylinder is entirely of cast iron, composed of a center section and two end sections, bolted and spigoted together, and all split horizontally. The three upper pieces are handled as one, the vertical joints never being disturbed. The high-pressure steam admission is controlled much the same as

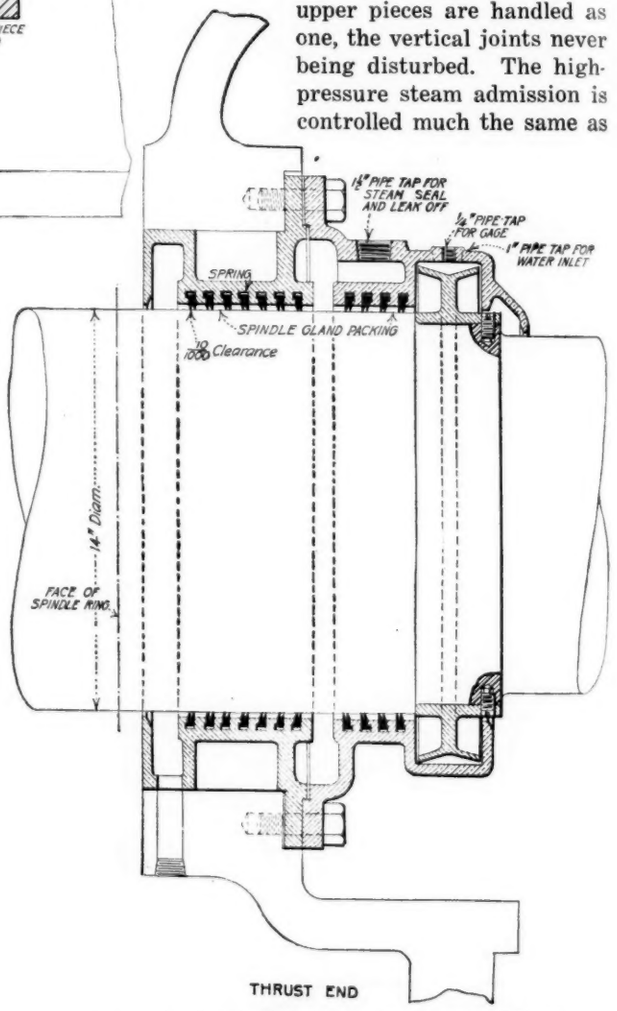


FIG. 7. SECTION OF GLAND FOR THE SHAFT

on all other Westinghouse machines, by means of a powerful, though sensitive, governor, Fig. 5, which operates the plunger of an oil relay attached to a floating lever, this relay controlling the admission of oil to an operating cylinder mounted on the side of the first, or primary valve. This cylinder by means of

levers, controls the primary, secondary and tertiary admission valves. The primary valve, located on the side, admits steam to the bottom of the high-pressure cylinder, while the secondary and tertiary valves, being located on the top symmetrically about the center line, admit steam to the second or third stage, as the case

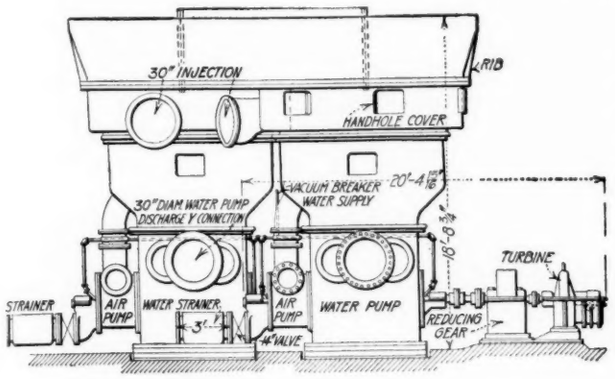


FIG. 8. THE LEBLANC TWIN CONDENSER

may be. Loads of 30,000, 40,000 and 50,000 kw. respectively can be carried on these valves.

The bearings employed on this unit are proportioned to preserve a satisfactory ratio between unit pressure and peripheral speed. They are lined with babbitt metal, supported on spherical seats and provided with positive adjustment in any direction. A liberal supply of oil is distributed through a groove along the top, while the sides of the bearings are eccentrically relieved for a distance of 35 to 40 deg. above and below the center line. This leaves an arc of 100 to 110 deg. for supporting the journal.

Both turbines are equipped with double Kingsbury thrust bearings, Fig. 6, capable of taking the load in either direction, though when running under load the thrust is toward the generator. Under normal operation they are loaded to about 300 lb. per sq.in., but are capable of safely carrying twice as much. The maximum peripheral speed is about 100 ft. per sec. These bearings are not only immersed in oil, but are supplied with a circulation of fresh oil through passages which deliver it near the center of the bearing.

The shafts are sealed with the usual water gland with the addition of an annular steam chamber for the admission of steam so that a vacuum can be established before starting the turbine. Water is turned on when the turbine approaches full speed and the steam is turned off. One feature of these glands is that they can be removed for inspection without lifting the cylinder cover. The glands are shown in Fig. 7.

Each turbine is provided with an oil pump sufficient for its own needs, though both feed into the same oiling system. They are double-plunger pumps, running at 165 strokes a minute, with a common suction but separate discharge.

The high-pressure oil necessary to operate the steam-inlet valves is taken from one side of the pump on the high-pressure turbine, pressure being maintained by a spring-loaded relief valve. The total amount of oil used is approximately 175 gal. a minute. The bearing oil pressure is from 5 to 8 pounds.

This unit, although it does consist of two separate elements, is started the same as any other machine. Field excitation is supplied to the generators, the throttle on the high-pressure element is opened and slowly brought up to speed, the low-pressure generator operating as a motor and coming to speed in step with the other. The two machines as a unit can then be synchronized and placed on the line, remaining in step and properly dividing their load.

The condenser equipment, Figs. 8 and 9, for this turbine consists of the largest condensing apparatus in the world. The condenser unit is composed of two separate and distinct low-level jet condensers, which can be operated together or separately, if necessary. If the temperature of the injection water is low enough to warrant it, the operation of only one condenser is necessary to maintain a workable vacuum. Each condenser has 90 injection nozzles arranged in three rows. See Fig. 9.

These condensers are connected to form a single condensing apparatus by means of an exhaust connection, ample in area to permit operating either condenser alone when necessary.

The same water level is maintained in each condenser by the use of a water-equalizing connection between one pump body and the other. This is a necessary feature, and it is provided to maintain a constant submergence over the center line of each pump to give sufficient head to force water into the runner under vacuum. This water-equalizing connection is so con-

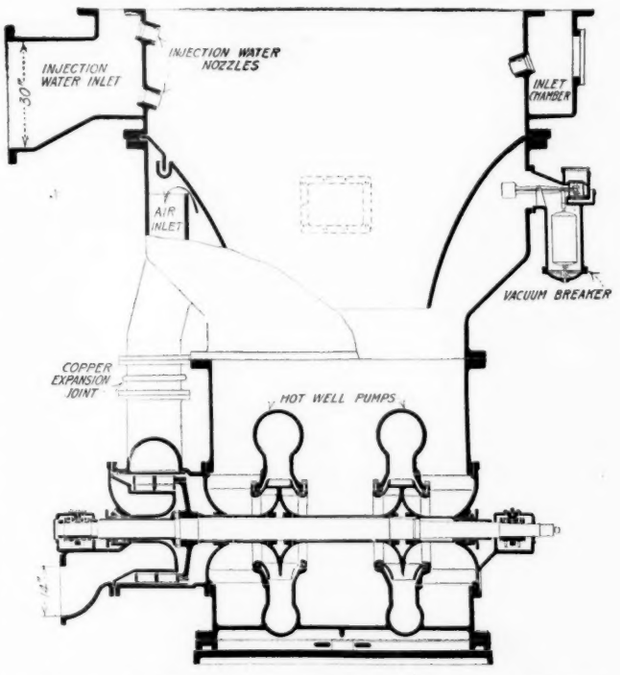


FIG. 9. SECTION OF CONDENSER; NOTE INJECTION-WATER NOZZLES

structed that no surges occur between the condensers, it being made in the form of a tee, the bottom of which forms a reservoir. A baffle running almost to the bottom prevents surging.

An air-equalizing connection is provided to maintain the same air pressure in each condenser. If both are in operation, the valve may be either open or closed, but it has been found by trial that if one condenser only is in operation, the valve must be open to have the same air pressure in each.

The condensers are equipped with geared turbine-driven pumps, running at 500 r.p.m. instead of 700, the latter being standard. This was found necessary, owing to the limited headroom in the basement. These pumps are able to operate with a submergence of 50 in. above the center line of the pump shaft, while 72 in. is necessary with a 700-r.p.m. pump. This resulted in a saving of 22 in. in headroom.

The water rates are as follows:

Kilowatts	Efficiency, per Cent.	Water Rate at 29 in. Vacuum
15,000	90.0	12.25
20,000	92.0	11.8
25,000	93.25	11.55
30,000	94.04	11.36
35,000	94.57	11.9
40,000	94.92	12.12
45,000	95.18	12.2

Considering capacity, this unit requires less floor space than any other condenser unit now in operation.

In starting up this condenser it is necessary to use a priming pump. The main turbine is operated non-condensing, or with a slight vacuum, until sufficient vacuum is obtained for the condenser to lift its own water.

As a matter of interest it may be noted that the Narragansett Electric Lighting Co. uses nothing but jet condensers. Its experience has been that while boiler-feed water is expensive, nevertheless surface condensers do not stand up under the extremely bad water conditions existing at Providence.

The twin condensers used with this 45,000-kw. turbine require 18,000,000 lb. of condensing water per hour, 9,000,000 lb. in each condenser. In addition to this 15 per cent. more is required for the operation of the air pump.

Polyphase Induction Reverse Power Relays

The polyphase-induction reverse-power relay here illustrated has been brought out by the General Electric Co. It will operate correctly on practically all single-phase short-circuits, even though the voltage between two lines which are short-circuited may fall to zero, on balanced three-phase short-circuits with 10 amp. secondary and 1 per cent. of normal voltage remaining and in practically every case on balanced short-circuits, with a voltage of one-half of 1 per cent. normal. The relay, Fig. 1, is constructed along the lines of a polyphase-watt-hour meter, but with three instead of two driving elements. Each of the elements has a current and a potential coil. Two disks connected to a single operating shaft are used, the upper one of which is driven by one element and the lower by two elements, one in front and one in back. The use of three elements is required for grounded Y circuits and is a distinct advantage ever when the relay is used on ungrounded circuits. For ungrounded circuits two current and two potential transformers are sufficient. The third current coil carries the resultant current of the two current transformers and the third potential coil is connected across the open delta of the two potential transformers.

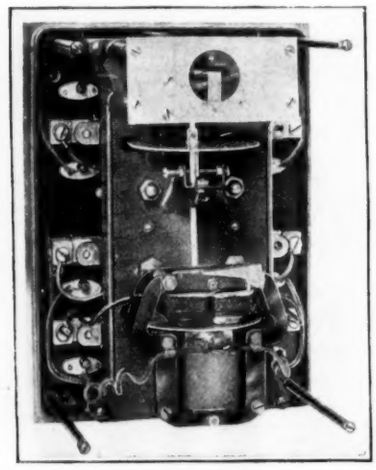


FIG. 1. INDUCTION POLYPHASE REVERSE POWER RELAY

The relays are built with single- or double-throw contacts which, however, carry for only an instant the tripping current of the automatic circuit-opening device because the closing of these main contacts sends the entire tripping current of the breaker being protected through the operating coil of an auxiliary relay within the case of the reverse-power relay and causes its contacts to close and short-circuit the main relay contacts. The auxiliary contacts are sealed closed by the tripping current until the trip circuit has been opened by means of an auxiliary switch on the air or oil circuit-breaker. The breaking of the tripping current by this auxiliary switch permits the auxiliary relay to open. Vibration is practically eliminated even at very heavy currents.

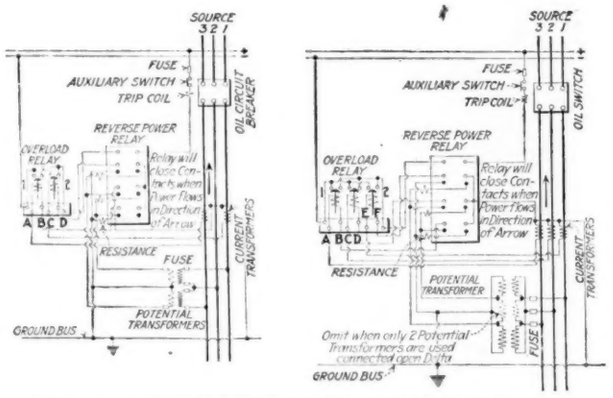


FIG. 2. CONNECTIONS FOR UNGROUNDED AND GROUNDED CIRCUITS RESPECTIVELY

The relays are made sensitive in order to operate properly on very low potentials. Thus, overload relays must be used in conjunction with the reverse-power relays to prevent operation at normal potential until a predetermined current and time are reached. The contacts of the overload and reverse-power relays are connected in series so that both must close to trip the breaker. Any type of overload relay can be used but the plunger type is recommended when instantaneous action is desired. The time and current settings of the overload relay determines the action of the combination. Fig. 2 shows the reverse-power relay connections for ungrounded and grounded circuits.

A good asphaltum cut down with turpentine to the right consistency makes a good paint for stacks and boiler fronts. Coal tar mixed with graphite and thinned with turpentine is a good paint also. Steam pipes used for heating should not be painted, but given a thin coat of lampblack and linseed oil to improve the looks.

A cement for closing leaks in iron pipe consists of coarsely powdered iron borings, 5 lb.; powdered sal ammoniac, 2 oz.; sulphur, 1 oz., and water sufficient to moisten it. This composition hardens rapidly, but if time can be allowed it sets more firmly without the sulphur. It must be used as soon as mixed and rammed tightly into the joint or leak.

The Electrical Study Course—Motor-Starting Rheostats

Explains why it is necessary to use starting devices in the operation of motors, and how the requirements for the various types of motors differ.

SO FAR we have dwelt on the manner in which motors are connected to circuits and the conditions affecting them, upon the assumption that they had already been started and were in operation. It will now be necessary to consider what the requirements of starting are and how they are met in practice.

We shall investigate the three ordinary types individually, beginning with the shunt, since it is the one most widely used. When in operation, the connections are those shown in Fig. 1, in which the field and armature are connected directly across the line. Now the field winding is of such resistance that it may be so

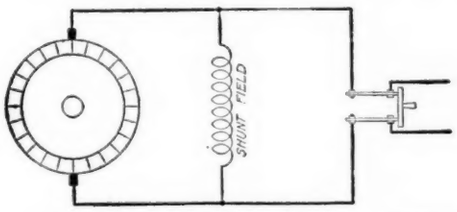


FIG. 1. DIAGRAM OF CONNECTIONS OF A SHUNT MOTOR AFTER BEING STARTED

connected and yet only its normal current will flow, but the resistance of the armature is very low, being so constructed purposely in order to keep its resistance loss as small as possible, and it is only the presence of the counter-em.f. when the armature is revolving which limits the amount of armature current to normal values. That is, as found previously, armature current $= \frac{\text{applied voltage} - \text{counter-em.f.}}{\text{armature resistance}}$, but when the armature is stationary there is of course no counter-em.f. present, its value therefore being zero, and consequently we would have, current $= \frac{\text{applied voltage}}{\text{armature resistance}}$; since the armature resistance is small, the current would be large. Let us determine the comparative magnitude of the various quantities in a motor of a given size, for example a 5-hp. 110-volt machine. Assume that the efficiency at full load is 86 per cent. and that the part of the internal loss at full load due to armature resistance is one-half the total internal loss. When the machine is running at full load it is delivering 5 hp., or $5 \times 746 = 3730$ watts, and this is $\frac{85}{100}$ of the electrical power it takes, since the efficiency is 85 per cent.; or power input $\times \frac{85}{100} = 3730$ watts, from which we have power input $= \frac{100}{85} \times 3730 = 4388$ watts. and the current used would be $\frac{4388 \text{ watts}}{110 \text{ volts}} = 39.9$ amperes. The loss in the motor is the difference between the input and output, that is, $4388 - 3730 = 658$ watts, and since the armature loss is one-half of the total, it is equal to $\frac{658}{2} = 329$ watts. If I represents the armature current, R the armature resistance and W the watts lost in the armature, we have $I^2R = W$, and for full load this would be 329 watts. Neglecting the field current, which is small compared with the full-load armature current, we have $I = 39.9$ amperes at full load, or practically 40 amperes. Therefore $I^2R = 40^2R = 1600R$, which was found to equal 329 watts; from which we have $R = \frac{329}{1600} = 0.206$ ohm. Were the armature to be directly connected to the mains as in Fig. 1, while at rest, we should have, armature current $= \frac{\text{applied voltage}}{\text{armature resistance}} = \frac{110 \text{ volts}}{0.206 \text{ ohm}} = 534$ amperes, or more than 13 times the full-load current. This high value of current would blow the fuses or open the circuit-breakers located in the supply circuit, and might cause damage to the commutator owing to severe sparking at the instant the circuit was closed.

It is evident from the foregoing that some means must be resorted to to limit the current taken at starting, and the simplest way of accomplishing this is to place a resistance in series with the armature sufficiently great to cut down the starting current to whatever value is considered requisite. As soon as current flows through the armature, it will begin to revolve, which will cause a counter-em.f. to be generated, which in turn will reduce the current, whereupon part of the resistance may be cut out, again increasing the current and hence the speed and counter-em.f., which reduces the current once more, whereupon still more resistance may

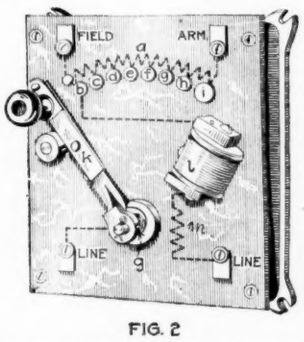


FIG. 2

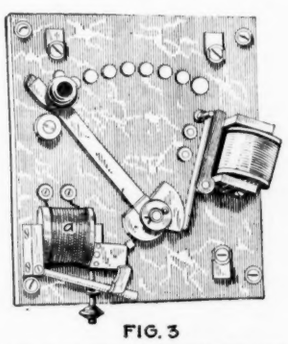


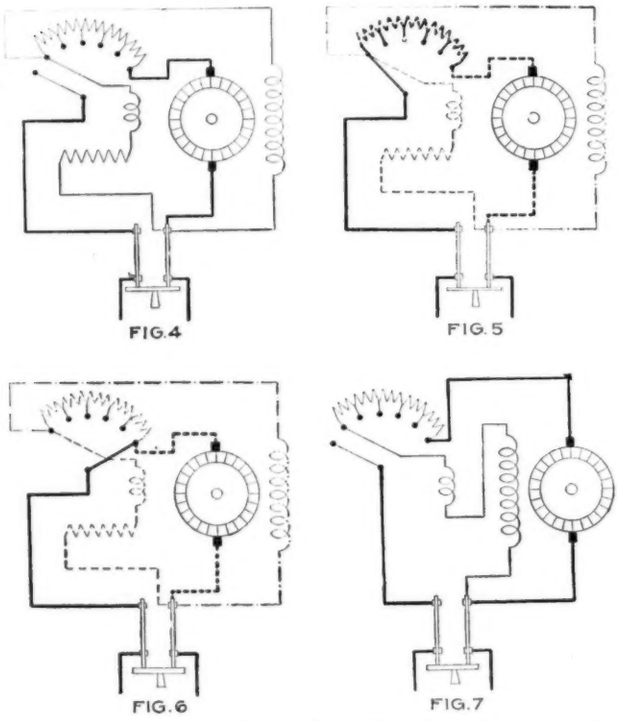
FIG. 3

FIGS. 2 AND 3. USUAL TYPES OF STARTING RHEOSTATS USED FOR SHUNT MOTORS

be cut out. This process is repeated until all the resistance has been taken out of the circuit so that the armature is finally connected directly across the line voltage. Such a device for bringing a motor up to speed from rest is known as a motor-starting rheostat, or more commonly as a "starting box." The number of steps in which the speed is brought from zero to full value depends on the design of the motor and upon the permissible current that may be taken from the service line at starting. If the line wire is of small carrying capacity, there would be a serious momentary drop in voltage in it if the motor were started with few steps of resistance, oc-

casioning large jumps in the current taken. This would be particularly objectionable if lights were being used from the same service. On the other hand, a line of large carrying capacity might have a heavy starting current taken from it without much disturbance of voltage. Often the motor design is the controlling factor. For example, a straight shunt machine will spark badly when subjected to excessive current in starting, whereas a shunt machine built with interpoles will behave a great deal better. The ordinary type of starting box has about half a dozen steps, which has been found to cover the average requirements.

Fig. 2 illustrates a typical starting box, the dotted lines representing the internal connections. There are



FIGS. 4 TO 7. DIAGRAMS SHOWING VARIOUS STAGES PASSED THROUGH WHILE STARTING SHUNT MOTORS

8 steps in the resistance a, which is connected to the contact buttons b, c, d, etc. The arm k may be moved across these, in so doing cutting the resistance out of the circuit. The magnet l is in series with the resistance m directly across the line-voltage. When the main switch is closed this magnet is excited, its function being to hold the arm k on the last contact by means of its attraction for a piece of iron attached to the arm; this bridges the poles of the magnet when the arm is brought to contact i. In moving the arm to i a spring at g is compressed, which snaps the arm back to the "off" position when the excitation of the magnet l ceases. This occurs when the main switch is opened or when the supply voltage fails for any reason. The arm k is thus prevented from remaining in position i where it would offer no protection to the motor if the voltage were to be restored or the switch subsequently closed. Fig. 3 illustrates a starting box similar to the one described and having in addition an "overload release" a, which consists of a magnet placed in series with the armature circuit, and which actuates an iron core when the current exceeds a fixed value, causing it to short-circuit the release magnet thus allowing the contact arm to return to the "off" position. Figs. 4 to 6 show the connections and paths of the currents for several steps which occur during the starting of a motor. Fig. 4 shows the conditions when the motor is ready to be started, Fig. 5 illustrates the first step and Fig. 6 the connections when the starting operation has been completed. In effect there are three circuits connected across the line; namely, the field, the armature and the release magnet. These are indicated by different kinds of lines to facilitate tracing out the path of the current through them. In some types of starting boxes the release magnet is connected in series with the field, in which case the connections are made as indicated in Fig. 7. It will be noticed that the field winding is connected across the full line voltage immediately upon moving the arm of the starting box to the first contact. The resistance of the starting box is gradually placed in series with it as the arm is advanced, but there is no appreciable change in the field current because the resistance of the coils in the starting box is only a very small fraction of the resistance of the field winding.

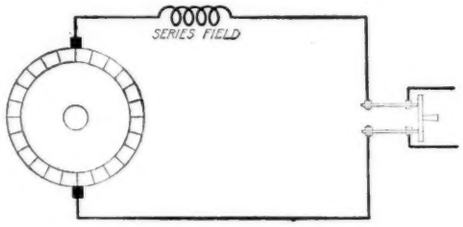


FIG. 8. DIAGRAM OF CONNECTIONS OF A SERIES MOTOR AFTER BEING STARTED

The resistance wire contained in starting boxes is not intended to carry current for any considerable length of time, not even the current taken by the motor at no load, and it will quickly burn out if subjected to such treatment. That is, the ordinary starting box is intended for starting duty only, as its name implies; moreover it is preferable that there should be no load upon the motor while being started, since it would take a great deal more time for the machine to accelerate under load than when unloaded, with a consequent increase in the time during which the starting box would be subjected to the heavy current.

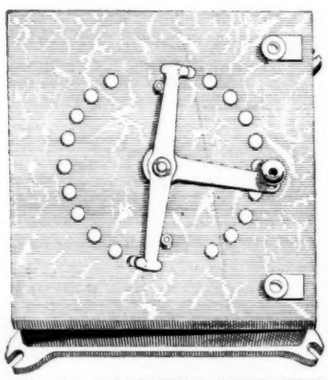


FIG. 9. STARTING RHEOSTAT FOR NON-REVERSING SERIES MOTOR

We now come to the series motor. In this type the connections are as shown in Fig. 8 when the motor is in operation. The armature resistance of such machines is of the same magnitude as that of shunt machines, and consequently we face the same problem of limiting the current when starting these motors. There is, however, this difference: The shunt motor is started with no load on it, and the starting resistance is intended to carry large current for only very short intervals of

time, whereas the series motor, from the very nature of the class of drive it is adapted for, must generally be started under load, and under maximum load at that. The material of which the starting resistance consists must therefore be much more liberally proportioned and be capable of carrying very large currents for considerable intervals of time. Not only must the resistance be more rugged, but the contacts must likewise be designed to handle the currents involved without suffering excessive destruction. In the smaller sizes series motors may be started with apparatus identical in principle with the shunt-motor starting boxes described, omitting the shunt-field circuit, but the larger sizes are usually operated by a starting device called a controller, which, like the starting box, consists of a set of resistances, but which is not usually provided with any automatic no voltage release, so that the contact arm will remain upon whatever contact it is placed. It is therefore necessary to be careful to return the controller to the off position whenever the main switch is opened or the supply voltage fails. A controller of this type is illustrated in Fig. 9, and the typical connection for it in Fig. 10. The controller shown is intended for a motor whose rotation does not require reversal.

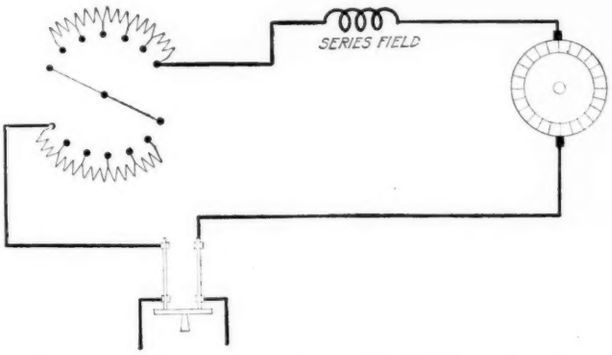


FIG. 10. CONNECTIONS OF SERIES-WOUND MOTOR

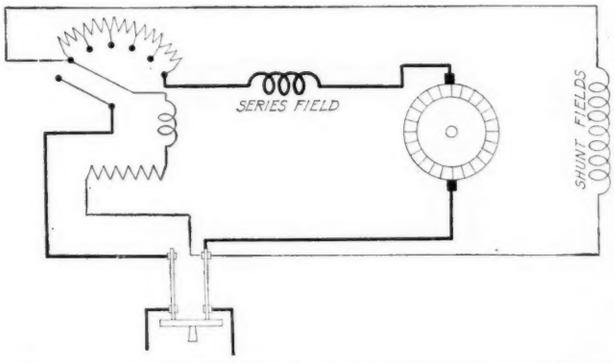


FIG. 11. CONNECTIONS OF COMPOUND-WOUND MOTOR

The remaining type to be discussed is the compound motor, and this introduces no new complications since it has a shunt-field winding which allows it to be run with safety at no load. It may therefore be started in the same manner as the shunt type and by means of the same type of starting box, the only difference in the connections being that the series-field winding is connected in series with the armature circuit. Fig. 11 is a representation of the connections.

The foregoing is a presentation of the fundamental facts regarding the starting of motors and illustrates a few of the simpler types of starting apparatus in practical use. The number of such devices is very great, and they are designed to meet every conceivable requirement of operation. Among them are automatic starters, remote-control equipment and multiple-unit systems for train operation. The complications which these introduce are due to the auxiliary apparatus necessary to perform the actual work of cutting out or cutting in resistance; the principle of starting is exactly the same as for hand operation; namely, that the armature is to be protected from too great a current by means of resistance in series with it.

In the problem of last week water is to be pumped into a tank 70 ft. above the ground from a well 90 ft. deep by means of an electrically driven pump whose efficiency is 60 per cent. The tank is 8 ft. in diameter by 10 ft. high and is to be filled in 5 hours. It is required to find what size motor it would be necessary to install to drive the pump.

The size of the motor will depend on the work it has to perform and the time in which it is to be accomplished. In this case the work consists in lifting a certain weight of water a given height in 5 hours. Let P represent the power required, expressed in horsepower, W the number of pounds of water to be lifted, H the number of feet it has to be raised and T the time in which it must be done. The number of foot-pounds of work to be performed would then be $W \times H$, and this would have to be accomplished in T minutes; hence, in 1 min. the work to be done would be $\frac{W \times H}{T}$ ft.-lb. Since 1 hp. is the equivalent of 33,000 ft.-lb. of work performed in 1 min., we have $P = \frac{W \times H}{33{,}000\ T}$. In our problem W can be found from the size of the tank, which is 8 ft. in diameter by 10 ft. high. Its capacity will then be $\pi \times \left(\frac{\text{diam.}}{2}\right)^2 \times$ height, or $3.142 \times \left(\frac{8}{2}\right)^2 \times 10 =$ 502.7 cu.ft. Since 1 cu.ft. of water weighs 62.5 lb., the total weight of water would be $502.7 \times 62.5 = 31{,}420$ lb. The height through which it must be raised is the distance from the well to the surface plus the height of the tank above the ground, or $90 + 70 = 160$ ft. The value of T is given as 300 min. Substituting in the equation $P = \frac{W \times H}{33{,}000\ T}$ we have $P = \frac{31{,}420 \times 160}{33{,}000 \times 300} =$ 0.508 hp. The efficiency of the pumping system is stated to be 60 per cent., hence 0.508 hp. $= \frac{60}{100} \times$ power required to be delivered by motor, or motor output $=$ $0.508 \times \frac{100}{60} = 0.847$ hp. That is, a 1-hp. motor would have to be provided.

The armature resistance of a 50-hp. 240-volt motor is 0.07 ohm. What value must the resistance of the starting box be in order to limit the starting current to 1½ times the approximate full-load current?

A room 15 ft. long by 10 ft. wide by 9 ft. high is to be heated electrically. If it requires 2 watts per cubic foot to maintain the desired temperature, what current would the heaters take if they are supplied from 110-volt service?

The Massachusetts Plan of Power-Plant Inspection and Coal Conservation

By THOMAS HAWLEY

Mr. Hawley is member-at-large of the Engineers' Advisory Committee to the Massachusetts State Fuel Administrator and chairman of the Combined Committee of Operating Engineers and Firemen, referred to in his article. In an address delivered at the Bridgeport convention of the New England States Association of the N. A. S. E. he announced that Massachusetts was not going to follow the Fuel Administration's plan of inspecting and classifying power plants but had a plan of its own. At our request he furnishes the following outline of the Massachusetts plan.

NEW ENGLAND at present is unfortunately situated in relation to coal, because the greatest part of its supply must come by water. The minimum amount of steam coal needed for New England was conservatively estimated at 34 million tons per year. The Washington authorities have cut this amount, and allotted in the spring not more than 30 million tons for New England. But it became clear very early in the year that even this amount would not be received, first, because the coal was needed for other purposes, and second, because there were not sufficient steamers or barges to bring the coal to New England. The press and people of the country urgently demanded that an effective army be promptly placed in France. Recent events have told us how well that work has been done, and we all glory in the achievement and its results. But to put such an army in France meant taking every ship possible. Whenever the question arose, "Which shall it be, coal for New England or supplies for our boys overseas?" there could be but one answer, and New England did not get the vessels. Later the number of steamers available was increased, but then the demand for coal for overseas work had so increased that we could not get the coal. The mines that supply New England by water must also supply our great fleet of warships, transports and freighters necessary for overseas work, and in addition they must supply the vast quantities of coal called for by South American and other countries that were formerly supplied by England, but that now demand our coal in exchange for those materials that we must have for a successful prosecution of the war. When coal arrives at the coal-shipping ports large quantities destined for New England are taken by the Government and diverted for war purposes. The result is that the summer months during which we must store coal have passed, and we are millions of tons behind previous years and with the usual reserve absorbed by the demands of last winter. Only by an unusually mild winter and a steady and uninterrupted supply is it possible to avoid a serious shortage of steam coal; and if the winter is only an ordinary one there is little chance of our supply equaling 25 million tons for the full year. New England therefore must conserve every pound of coal. We cannot expect to make up the full deficiency, but by the sustained efforts of all steam producers and all steam and power users we do expect to prevent the shutting down of many industries and avoid all the misery that this entails. The Massachusetts plan contemplates accomplishing this in the following manner:

First, by making every engineer and fireman and every person having anything to do with the use of light, heat and power, feel a deep personal responsibility and pride in saving coal.

Second, by directing this work in every factory and building through the establishment and constant watchfulness of a committee of employees.

Third, by learning through reports from interested persons, or by regular inspection, of plants that are generally wasteful, and compelling better equipment if possible, and better practice in the power plant but also in the factory and building.

Engineers Study Conditions

The engineer will study his boiler and engine room and recommend such conditions and changes in equipment as will produce steam and power at a lower cost in coal. Further, he is expected to devise better methods and practice in firing, and in the use of all the auxiliaries in the boiler and engine room. If his domain extends into the factory he will make a study of the uses of steam and the power, cut out unnecessary heating and lighting, reduce the power of lamps, use more efficient lamps, subdivide heating so that rooms may not be overheated, align shafting to reduce friction, subdivide belt drives so that all the shafting will not need to be run if not needed, divide the work and boiling processes in the factory if possible so that the boilers and engines have a steadier load, arrange for the notification of the boiler room in advance of sudden increases in load, find a larger use for exhaust steam in all processes, regularly reduce the back pressure on the engine when all the exhaust steam is not used, reduce live steam pressure upon many processes in the factory if it is not possible to use exhaust steam therein, return all hot-water drips for use again, obtain the highest feed-water temperature, repair leaky traps and vacuum valves, overhaul pumps and keep them tight and running full stroke; also setting and overhauling valves and pistons of engines.

Overheating and Overventilation

In office buildings much of the overheating and overventilation will be cut out and air will be taken from clean basements instead of from outdoors. We will seek to reduce the pressure on the elevator tanks, particularly at night, to reduce the number of trips, to reduce the speed of elevators, to rearrange elevator service so that certain elevators will not go beyond certain floors, to close unnecessary doors about the building, to cut down unnecessary heating when the building is not occupied, to cut down excessive lighting in halls and many other parts of the building, to sub-

divide the heating system, as well as to keep a closer watch for losses in the boiler, engine and pump rooms.

In air-compressor plants a saving can be made by readjustment of the pressures; by overhauling the pipe lines, valves and triggers to prevent the leakage so common and so expensive as it calls for steady work from uneconomical compressors; and in cases by the substitution of the vastly more economical electric apparatus for the pneumatic tools so frequently used.

Probably many of these things will come under the master mechanic or the chief electrician and not the engineer, but there is needed a closer coöperation between them, as well as a more enlightened attitude of the engineer toward his fireman. The fireman is expected to keep eternally in mind the fact that every shovelful of coal he wastes is helping the Kaiser, and that every shovelful be saves is helping win the war; and if the firemen of the state are thoroughly aroused in this matter, they can accomplish an immense saving. They have promised through their organizations to do all in their power to this end.

The Individual's Part

The individuals in the factory will be expected to do their part by preventing unnecessary lighting, keeping doors and windows shut when not needed, not starting machines until actually ready, not leaving them running except when actually needed, not starting boiling or cooking processes in advance of time needed nor leaving them turned on after the work is done, and in any other way by which heat or power may be saved.

Every city and town in Massachusetts has its own local fuel committee and a part of its work will be to stimulate and keep up interest in the faithful carrying out of this programme of coal conservation. To do this, every factory or building, whether it generates its own power or obtains light, heat and power from outside, will be asked to appoint a Factory Fuel Committee. Usually the superintendent, chief engineer, fireman, electrician, and such foremen and watchmen as may be deemed necessary will constitute the committee, and at weekly meetings will compare notes as to what has been done toward fuel and power conservation that week and what plans might be taken for further saving. Already in Massachusetts, over sixty per cent. of the steam plants and factories have appointed such individual fuel committees. These were appointed as a result of appeals by mail from the Fuel Administrator at the State House in Boston, and from appeals from the local fuel committee, or as the result of meetings held to consider the matter of coal saving. In Boston I organized for the Boston Fuel Committee a force of 40 men, mostly first-class engineers, each of whom was given a certain district and personally presented the matter to the steam users of that district. This involved a statement of the necessity, what could be saved by the factory fuel committee, how it should do its work, and on that particular plant to advise in a general way how savings might be made. This committee of engineers was successful enough to enlist nearly all those approached, and factory committees have been thus formed and are already at work in very many of these plants. This committee of engineers, enlarged, will be useful later in carrying out the work as experience indicates.

My purpose in addressing the N. A. S. E. convention at Bridgeport was to enlist its active support in a campaign for fuel saving. The convention enthusiastically voted to do this and appointed an educational committee, instructed to make fuel conservation the special study of all the associations, to the practical exclusion of other topics. Every local association has appointed a committee to direct this work in that association and to keep up the interest of its membership. Some of the branches of the International Union of Steam Engineers, and the Brotherhood of Stationary Firemen have also appointed local committees for this purpose and it is expected that all will have done so shortly. These various committees of engineers and firemen in Greater Boston have combined into a central committee and are holding weekly meetings and laying out systematic plans for an intensive educational campaign among the engineers in Greater Boston so that the work may be more quickly got under way.

It is impossible to depend in Massachusetts upon the same plan as is to be tried by the United States Government in other states, that of appointing inspectors to classify power plants according to their equipment and practice in using coal economically and allot coal according to these classifications. The license law in Massachusetts has for 23 years been so rigidly enforced that engineers and firemen have learned how to study. Therefore it is very easy and natural to direct their study toward fuel conservation. Who can measure the benefit already obtained by the state in this emergency, from the greater intelligence of its operating engineers and firemen that this license law has brought about? We have therefore a very efficient body of men to work with. I believe any system of inspection by such inspectors as can be hastily gathered cannot begin to save as much coal as the intelligent, earnest efforts of all those who make steam and use it. An inspector must at best make a hurried inspection, and such an inspection is more than likely to see only surface losses. He may find a plant perfectly equipped and apparently in the highest class at the time of his visit, and yet the actual operation of that plant from day to day, in the steam plant, and through the whole factory, may be very wasteful. Large numbers of cases may be cited of excellently equipped plants that have saved large amounts of coal by paying closer attention to personal operation, eliminating small losses, but principally by the savings accomplished in the use of the power and steam after it left the power plant. There is very little opportunity now for extensive changes in plants and their equipment, not only because of the short time available to make the changes, but because of the difficulty in getting the new equipment. Furthermore we want the saving to begin now, by the voluntary effort of all concerned, and not be delayed until an inspector appears, and to do this without injecting the element of compulsion if it can be avoided.

Power Users To Conserve Coal

Massachusetts is going to rely on the deep interest and patriotic desire of its engineers, firemen and steam and power users, to conserve coal. This plan has already brought to light many plants where important changes should be made, and with the keen interest shown it is very certain that needlessly wasteful power plants and

factories will soon be detected, and thus all the advantages of the inspection system be obtained. If we reversed the process and depended principally upon an inspection system, with the hope that the factories will appoint fuel committees, precious time will be lost, the great savings possible throughout the factory will not be obtained, and the result in Massachusetts at least will not be as satisfactory.

Everyone has a keen desire to do something toward winning this war. Every engineer and fireman can contribute more largely than he realizes to that end by close coöperation in the conservation of coal. I have addressed many meetings of engineers in many parts of the State upon this matter and the response is most earnest. In localities where there is neither association nor union, engineers and others are forming committees to work together for more effective action. These committees will canvass that locality and all coöperate in determining how savings may be made so far as the engineers and firemen are concerned. The factory fuel committees will see that the interest is kept up toward savings in other parts of the factory. In this way we have a universal inspection system that will include not only the power plants but also every department where light, heat and power are used, as well as a will to save coal. Massachusetts has never failed yet in any undertaking that called for the earnest help of her citizens, and by the close coöperation of all we will, in this emergency, show the country an example of coal conservation worthy of note.

Preventing Explosions in Waste-Heat Boiler Settings

BY E. STANDIFORD

Certain explosions are liable to occur during the reversing of gas valves while operating openhearth furnaces, the force of these explosions ranging from little puffs to very heavy ones. They are caused by a mixture of the fresh air with carbon monoxide, which must be made to pass off during this operation of reversal.

Many explosions, often unnoticed because of the furnaces being directly connected to a stack, become pronounced when boilers are installed; therefore the flues and settings should be kept tight. It was at first feared that when waste-heat boilers were installed heavy explosions would have a disastrous effect on the connecting flues and the boiler settings, and because of this danger especial attention should be given to proper buckstay construction and sufficient explosion doors should be provid.d to relieve the pressure inside the settings should an explosion take place.

By the proper manner of reversing the valve operation, we have found by experiment that this difficulty can be practically overcome. Explosion doors can be so designed as to overcome the possibility of injuring and ruining the settings. A most important point is to avoid opening up the stack valves from the gas and air checkers at the same time or so near together as to permit the hot producer gas and air from the checkers to mingle and ignite inside the flues or boiler settings.

When using this way of reversal, the air-stack valve is opened just long enough after the opening of the gas stack to permit the gas that has settled in the checker to pass away and mingle with the existing gases before the hot air is admitted into the flues by the opening of the air-stack valve. When reversing the operation, care should be taken in regard to the corresponding gas and air-stack valves.

In plants where this system of valve operation is carried out, explosions are often reduced from 40 a day, varying in intensity, to but four in 411 consecutive reversals, ofttimes in a period covering five days. A heavy explosion is often due to leakage of a hydraulic valve which, through an operation of the ram, causes the gas valve to unseat.

Another system is where interconnected valves are used, sets of valves being operated simultaneously. Perhaps the best method would be a combination of the two systems; that is, the valves interconnected to assist in their manipulation, but so fixed that the first-mentioned order of control will be followed. The connections should be designed so that enough time will elapse between opening the stack valves and the gas and air valves to make it impossible for the hot producer gas and air to combine.

There has been a great saving throughout the United States by the installation of waste-heat boilers with openhearth furnaces. There has been installed over 90,000 rated boiler horsepower for this class of waste-heat work alone.

Generator Overcompounded

BY E. C. PARHAM

When a generator compounds "Flat," it means that the strength of the series winding is so adjusted as to keep the voltage constant at the terminals of the switchboard. When a generator overcompounds, the adjustment of the series winding is such that the voltage at a more distant point is maintained constant while the voltage at the switchboard varies with the load. The series windings generally are strong enough to overcompound the machine, unless they are shunted, and normally it is the adjustment of this shunt that determines the degree of compounding. In order to get proper regulation, it is essential that the no-load voltage be adjusted to normal value after the shunt-field winding has reached operating temperature, because heating of the shunt windings decreases the amount of current that they will take and thereby also decreases the voltage to which their current is due. The field-rheostat position corresponding to the proper adjustment should be marked. An operator complained that his 240-volt compound-wound generator had developed a tendency to overcompound, and he called an inspector to find an explanation of it. The first step was to check the speed, because high speed so often is responsible for overvoltage. The speed was found to be a little below normal. Preparatory to checking the position of the brushes and the adjustment of the series field shunt, the inspector proceeded to adjust the no-load voltage to 240 volts by means of the shunt-field rheostat. This adjustment was found to be impracticable. The lowest voltage obtainable with the rheostat turned to "All In," was 255 volts. This result fixed the responsibility on the rheostat, and inspection disclosed that a part of the rheostat was short-circuited by a piece of fish wire that had fallen through a perforation of the rheostat case. The removing of the fish wire restored operating conditions to normal.

Soot Removal from Fire-Tube Boilers

Rear-end and front-end blowers for return-tubular boilers, rocking elements for internally fired boilers and gear-turned blowers for vertical boilers.

IN PREVIOUS articles the need for mechanical soot removers in water-tube boilers has been shown and the various types used have been described. For this type of boiler the advantages of a permanently applied soot-blowing apparatus are so generally recognized that it is included in the equipment of most modern plants. As much cannot be said of the fire-tube boiler. Despite the fact that on the whole its economy is more rapidly affected by deposits of soot on the heating surface, less attention is paid to this factor. Soot is removed at irregular intervals, usually when a serious drop in capacity or excessive fuel consumption makes it imperative, and dependence for cleaning is more often placed on the hose and nozzle. The surface, of course, is more accessible than in the water-tube boiler, but with the hand lance the task has disagreeable

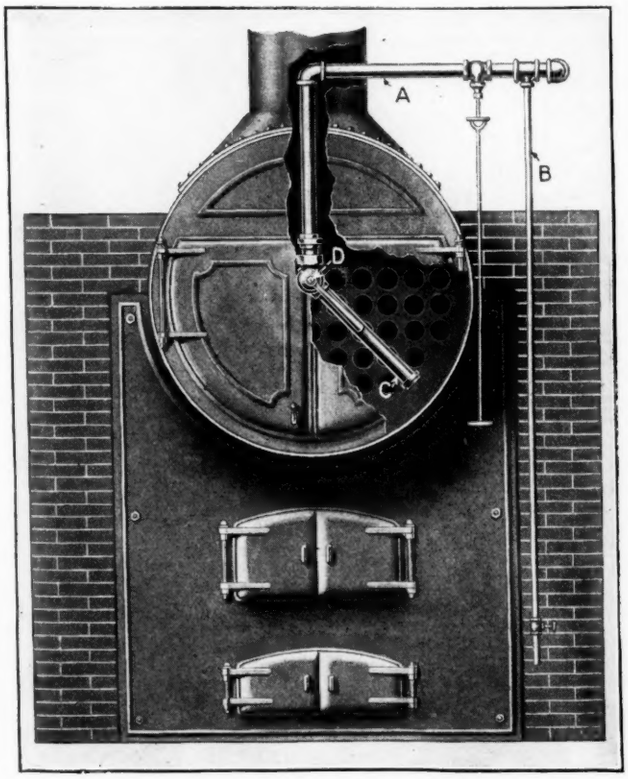


FIG. 1. BAYER SOOT BLOWER AS APPLIED TO A HORIZONTAL RETURN-TUBULAR BOILER

features tending toward infrequent cleaning and corresponding loss in efficiency.

There are a number of good blowers for fire-tube boilers on the market. For return-tubular boilers there are two general types, designated by their location as rear-end and front-end blowers. For years engineers demanded the former type, as it blew with the draft and was supposed to more efficiently clean the boiler. Recently, however, the front-end blower has come into favor because it is much easier to install and upon trial has been found to operate just as efficiently as the older type. It is mounted in the smokebox, so that there is no occasion to go through the brickwork as in the case of the rear-end blower. The front-end location

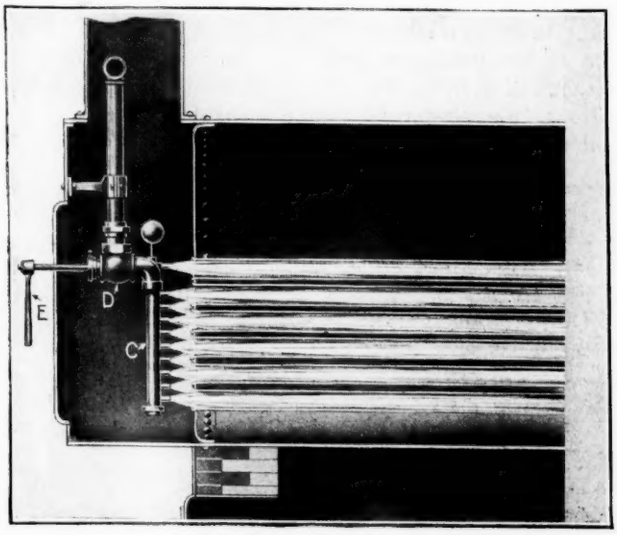


FIG. 2. SECTIONAL VIEW SHOWING OPERATION OF BLOWER

is more convenient, and as the temperature of the flue gases is considerably lower at this point, deterioration of the blower is not so rapid. With the rear-end blower provision was usually made to withdraw the nozzle after the boiler had been cleaned. Experience has shown, however, that quite frequently the blowing element was left in the path of the hot gases and was rapidly destroyed. In addition some of the blowers did not discharge the steam directly into the tubes so that their action was not particularly effective.

Blowing against the draft with the front-end blower has not seriously interfered with the operation of the boiler. Only a few tubes are blown at a time, and with all boiler doors closed, a pressure is created, so that the draft in the remaining tubes is greater than before. With the flue doors also closed, there is no opportunity for cold air to enter the boiler. This, of course, is a feature of both types of mechanical blower in contradistinction to the use of the hand hose.

A front-end type of blower made by the Bayer Steam Soot Blower Co. for horizontal return-tubular boilers is shown in Figs. 1 and 2. Referring to Fig. 1 the steam-supply pipe *A* may be connected to the main header or directly to the steam dome of the boiler itself. The drain pipe *B* is opened just before the blower is to be operated to remove condensation. As the supply pipe extends for a few feet in the uptake and front end of the boiler in the path of the flue gases, the steam is slightly superheated before reaching the nozzles.

The blower itself consists of an arm *C*, Fig. 1, connected to the steam pipe by the swing joint *D*. The axis of the joint is on the center line of the middle

tube of the top row, but this position is varied according to individual conditions. The blower arm to which the nozzles are fitted is oscillated by the lever *E*, Fig. 2. Each nozzle blows directly into the tubes in the arc it traverses. Above the blower element a counterweight is employed to steady the movement of the arm and to hold it at any point of the travel. A flanged union is provided on the steam line just above the doors so that the unit can be disconnected and removed from the smokebox. The operating lever is made to fit in a socket in the body of the swing joint, and is removable, so that the doors may be opened without disturbing the blower element. With modifications this blower is also applied to Scotch-marine boilers, one, two or more elements being employed

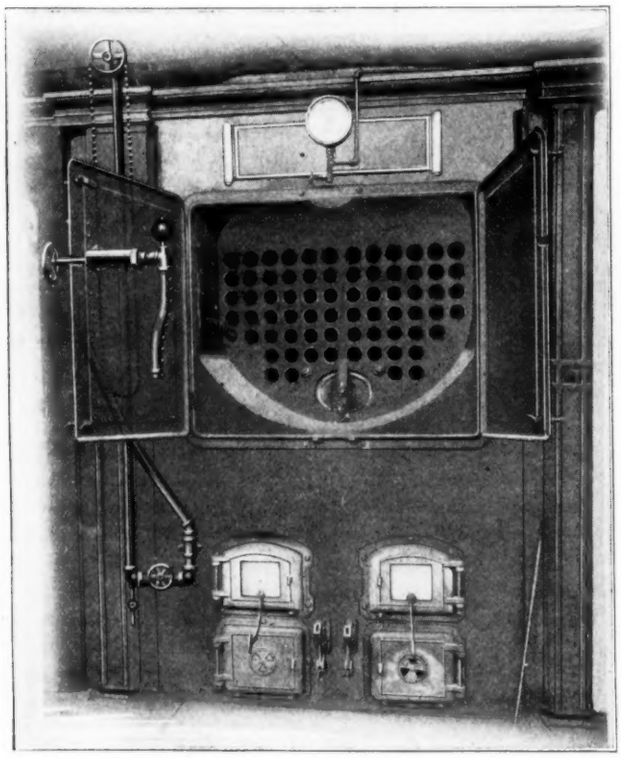


FIG. 3. DIAMOND FRONT-END BLOWER FOR HORIZONTAL RETURN-TUBULAR BOILERS

according to the size of the boiler, the number of furnaces and the layout of the flues.

The Diamond front-end blower for horizontal-tubular boilers is shown in Fig. 3. It consists of a revolving arm carrying venturi nozzles, which is turned by a handwheel on the outside. The blower is bolted to the door and, when the latter is opened, swings out with it, leaving the boiler end free for inspection or repairs. A swivel coupling, opposite the firing door in the illustration, makes it possible to open the boiler doors without disconnecting or cracking the blower piping.

Long before the foregoing type was designed, the Diamond rear-end blower, Fig. 4, had been in service and is still used where the conditions require it. It is permanently located in the rear wall of the setting and has the advantage that it is automatically withdrawn from the current of hot gases when not in service. The device is bolted to the rear wall, an exterior sleeve passing through the brick. Within the sleeve a piston-like nozzle head may be moved back and forth. When the blower is not in operation, a spring holds the nozzle back in the sleeve. When the steam is turned on, the pressure forces the nozzle against the action of the spring to the edge of the combustion chamber, where it is revolved to cover all the tubes by means of a handle exterior to the setting. A dial

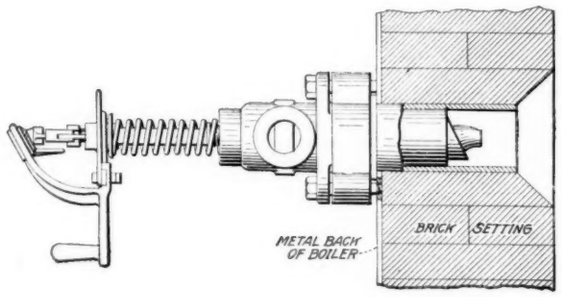


FIG. 4. DIAMOND REAR-END BLOWER

and pointer show the position of the nozzle at all times. As soon as the steam is shut off, the spring forces the nozzle head back into the sleeve, where it is protected from the heat.

In the Scotch-marine boiler this type of blower is installed through the rear water-leg, a hole being cut in the plates and a section of boiler tubing expanded

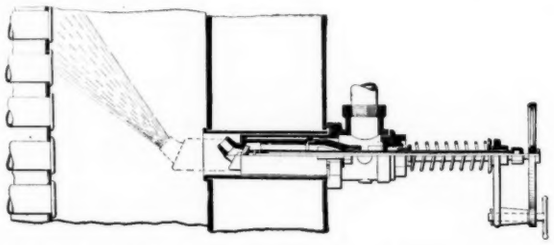


FIG. 5. REAR-END BLOWER SERVING SCOTCH-MARINE BOILER

and beaded into place. The blower is incased in this tubing, as illustrated in Fig. 5. The nozzle is operated by means of a crank and gearing. It is first rotated around the outer circle of tubes, then on the next inner circle and so on. With large boilers two and even three blowers may be used. A number of different designs of oscillating front-end blowers for marine

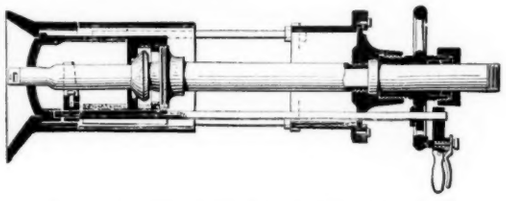


FIG. 6. MONARCH REAR-END BLOWER

boilers have been perfected, but space will not permit going into detail.

A rear-end blower, Fig. 6, for return-tubular boilers, somewhat similar to the foregoing design, is made by the Monarch Soot Remover Co. It is installed in the rear wall and has a piston-shaped head operating in a cast-iron sleeve. Two jets issuing from a double nozzle clean the tubes in the two outer circles when

the nozzle is revolved by a handwheel outside the setting. Adjustment by means of a ratchet lever shifts the jets to the inner circles of tubes, the operation being repeated until all the tubes have been covered. the latter, a steam-tight hinged joint in the supply pipe in line with the door hinges being provided. The blower has two distributing arms with internal nozzles welded in and spaced to cover the tubes. The

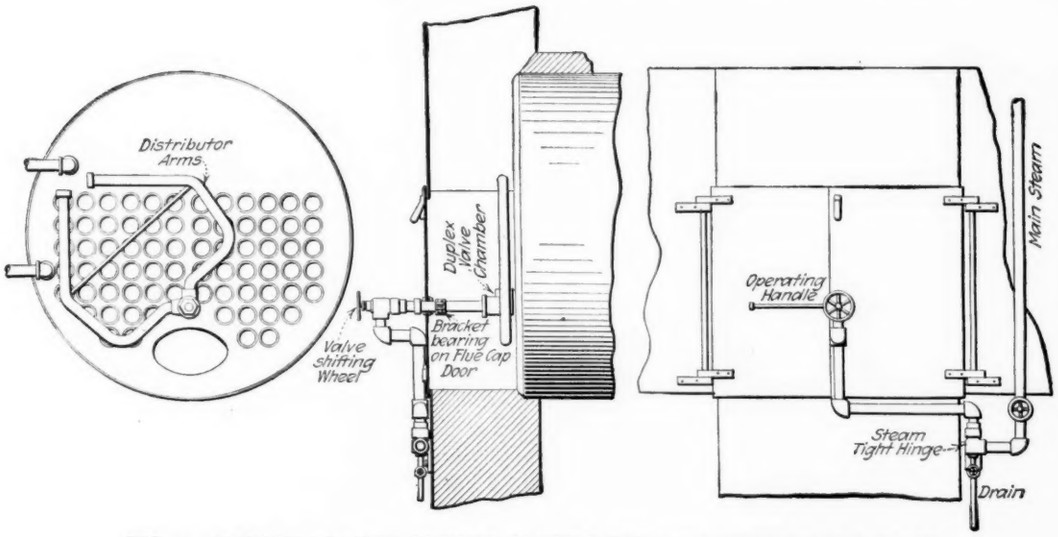


FIG. 7. MARION PLANET DUPLEX BLOWER FOR RETURN-TUBULAR BOILER

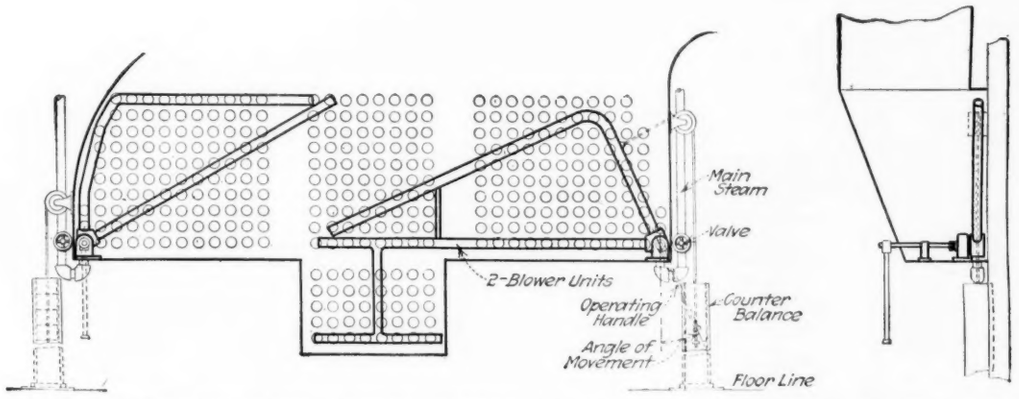


FIG. 8. MARION PLANET DUPLEX BLOWER ADAPTED TO SCOTCH-MARINE BOILER

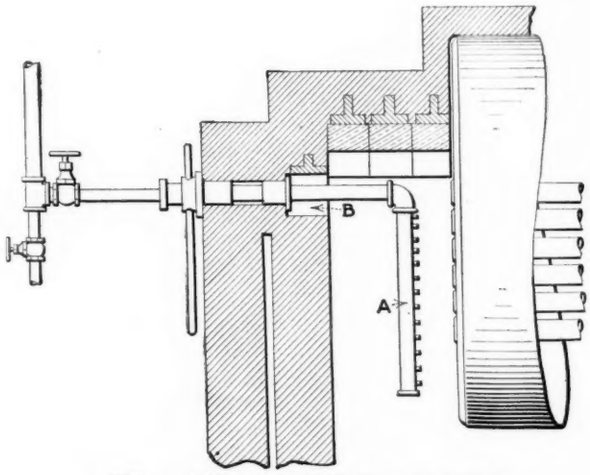


FIG. 9. VULCAN REAR-END BLOWER

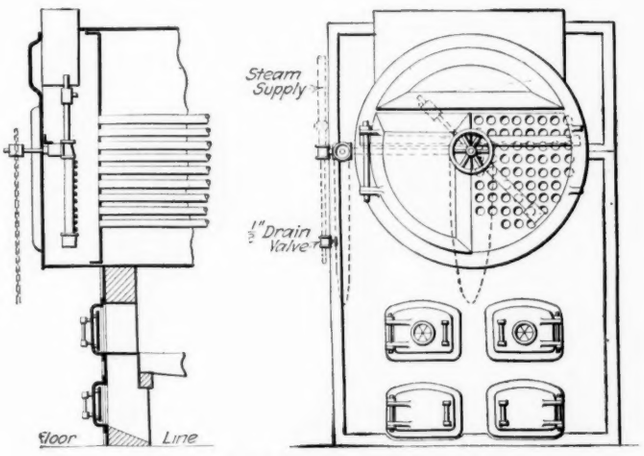


FIG. 10. VULCAN FRONT-END BLOWER

The Marion Planet duplex front-end blower made by the Marion Machine, Foundry and Supply Co. is shown in Fig. 7. It is supported by a bracket bearing on the flue-cap door and so that it may swing with arms are shaped to follow the marginal tubes so that they can be oscillated close up to the tube sheet without coming in contact with feed lines or any projection beyond the head. The valve chamber carrying

the two arms admits steam to each alternately and independently of the other.

The marginal tube construction of distributor arms has been developed for use on Scotch-marine boilers. In most cases two blowers will cover the entire tube area, as in Fig. 8. As before, steam is admitted to the arms alternately through a duplex valve. Each element is counterbalanced and is oscillated by means

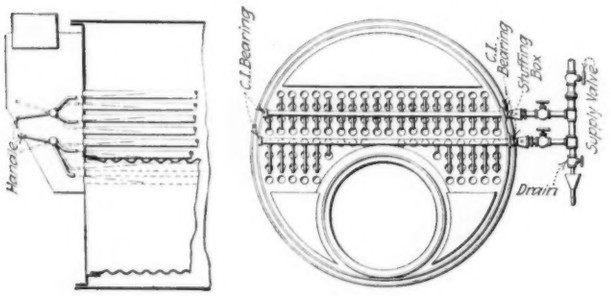


FIG. 11. VULCAN SOOT CLEANER OF ROCKING TYPE FOR SCOTCH-MARINE BOILER

of a handle or a sprocket and chain attachment located on the side of the flue cap.

Both types of cleaner for return-tubular boilers are made by the Vulcan Soot Cleaner Co. Fig. 9 shows the rear-end blower. It consists of a movable element *A* which swings in a half-circle across the tube sheet. Nozzles are spaced on the arm to cover every tube in the boiler during a single pass of the cleaner. The blowing is in the same direction as the draft. When not in operation, the arm is pulled back into the recess *B*, where it is protected from the gas current. To blow the tubes the arm is pushed from its recess in

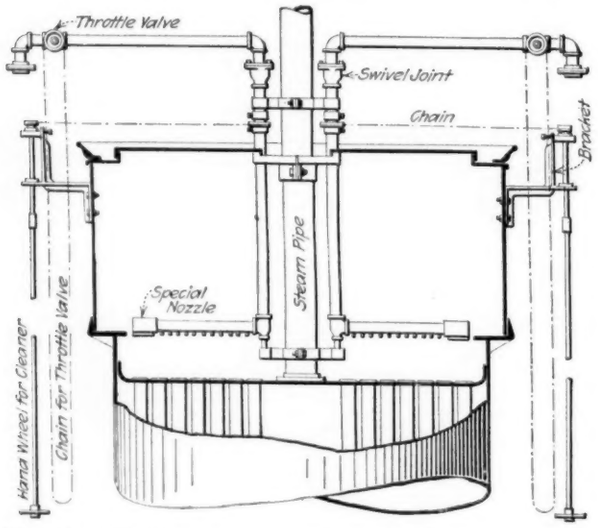


FIG. 12. VULCAN DOUBLE-ARM CLEANER FOR MANNING BOILER

the rear wall and is rotated by means of a handle from outside the setting.

The Vulcan front-end cleaner, Fig. 10, operates on the same principle. No protecting recess is required as the temperature of the flue gases is comparatively low at this point. The cleaner may be operated by a chain and sprocket or by a handwheel. The throttle valve is operated by a chain. The steam-supply pipe enters the smokebox at the side through the boiler shell. The cleaner is not fastened to the doors, but is supported on an angle iron which is bolted to the sides of the door frame. By removing the sprocket or handwheel the doors can be opened, leaving the cleaner in place. To remove the cleaner, it is necessary to break a union and remove the bolts in the angle iron.

Internally fired boilers offer much the same problem, except that space is not always available at the rear. Fig. 11 shows Vulcan rocking cleaners applied to a Scotch-marine boiler. The elements extend across the front of the boiler through the smokebox. They are provided with bearings, stuffing-boxes, valves and rocking handles outside of the boiler. Each element cleans four rows of tubes, two at a time. When the first two rows have been cleaned, the handle is rocked to bring the nozzles opposite the tubes in the two remaining rows. In many cases a combination of two front-end cleaners is used for the Scotch-marine boiler, the design depending on the tube layout.

Vertical fire-tube boilers are not immune from soot deposits. As the impression that soot will drop off vertical tubes by gravity is erroneous, cleaners are just as essential as in the case of the horizontal boiler.

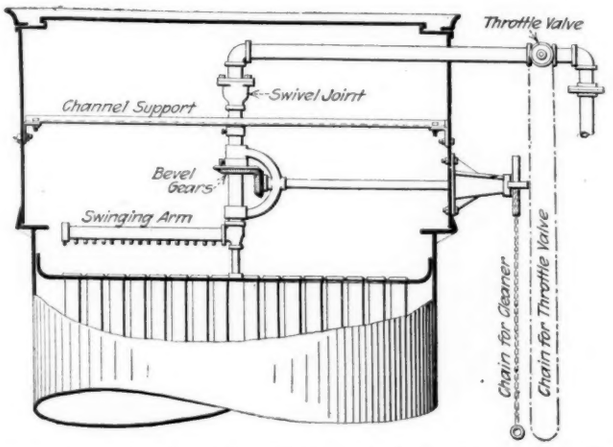


FIG. 13. SINGLE-ARM VULCAN CLEANER FOR MANNING BOILER

Figs. 12 and 13 are typical Vulcan installations applied to a Manning boiler. With the steam pipe located at the center on top of the drum, two cleaning elements are employed. Their arrangement and the method of operation are indicated in Fig. 12. In Fig. 13 a single element does the cleaning. The gears and the swivel joint are located inside of the smokebox. Rotation is effected by means of bevel gears, a ratchet wheel and a chain within reach of the floor or an operating platform.

It has been shown by experiment that the sulphur contained in coal in the form of pyrites is not the chief source of spontaneous combustion, as was formerly supposed, says the *Engineer*, but the oxidation of the sulphur in the coal may assist in breaking up the lumps of coal, and thus may increase the amount of fine coal which is particularly liable to rapid oxidation. Even this opinion is not unanimously endorsed. In spite of experimental data showing that sulphur is not the determining element in spontaneous combustion, the opinion is widespread that, if possible, it is well for storage purposes to choose a coal with a low sulphur content.

Influence of Liners on Rod Length

There has been in times past a great deal of discussion, pro and con, regarding the influence of liners or "shims" on the length of a connecting-rod. While the question probably deserves to be relegated to the same musty lumber room as "Does the crosshead stop at the end of the stroke?" and others of the kind, the fact that it has lately been revived in a thoroughly sincere and earnest manner seems to justify space to set forth what some may consider the obvious. To begin with, the length of a connecting-rod is understood to be the distance between the centers of the two pins that it connects. It is also to be understood that in this discussion placing liners in any given position means, not simply the one operation in which the act of inserting a liner may or may not be offset by a change in the position of the wedge, key or other adjustment, but refers to the

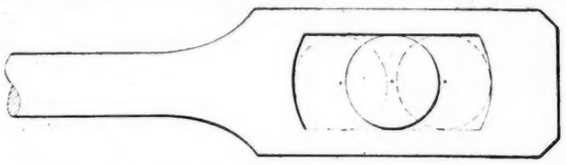


FIG. 1. EYE OF ROD SO WORN AS TO FORM A SLOT

practice, as in the continued operation of an engine or other machine—in other words, an act or practice which, if repeated or persisted in as a means of taking up wear, would result in a marked lengthening or shortening of the connection between the pins.

It is obvious that by wear the eye of a double-acting connecting-rod will become elongated or developed into a slot (shown exaggerated in Fig. 1) and result in the rod becoming longer when in tension and shorter in compression. That is, any wear toward the end allows the pins to get farther apart and likewise wear toward the middle allows the pins to approach that much nearer each other. If, therefore, the wear is taken up on each side of the pin, an amount just equal to that wear, the pin will retain its original position and the length of the rod will remain the same. If the wear is all taken up on

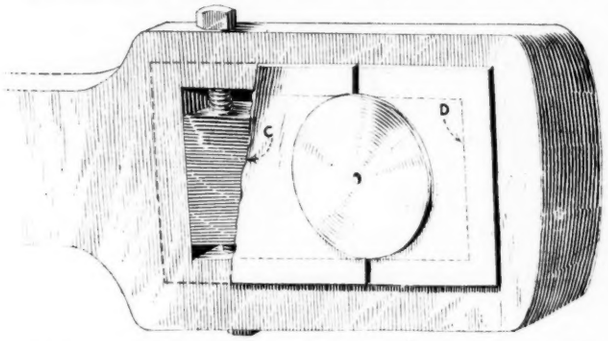


FIG. 2. TAKING UP ALL WEAR AT *C* BY WEDGE OR LINER LENGTHENS ROD

either side alone, then the rod length will have been changed to the extent of the wear on the side opposite to that on which the adjustment is made. Or if the wear is equal on both sides, the length of the rod has been changed to the amount of one-half the wear taken up.

In practice, however, the wear is, as a rule, taken up gradually, as required, by the key or wedge adjustment, until its limit is reached; then the key or wedge is released, and a liner is put in back of the brass on one side of the pin or the other. It is at this time that confusion is likely to occur in the mind, for if the wedge is simply "backed up" and a liner slipped in front of it, as at *C* in Fig. 2, there is no immediate change in the position of the pin because the wedge has been moved back the thickness of the liner, which is equivalent to shortening the rod by one means (backing up the wedge) and lengthening it an equal amount by another means (inserting the liner), the net result of the two being zero or no immediate change in the rod length. But if it is borne in mind that the position of the pin has been changing gradually all of the time of operation and that the wear has been taken up, a little at a time, all on one side of the pin by the adjustment, it will be seen that eventually the pin would be considerably beyond the orig-

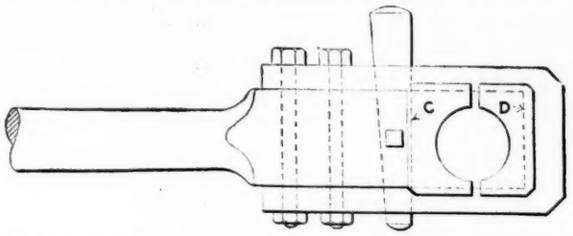


FIG. 3. ADJUSTMENT SIMILAR IN EFFECT TO FIG. 2

inal position in a direction opposite to the adjustment.

There is another point on which there must be no confusion; namely, in speaking of the side or point of adjustment, the design of the rod end or stub end must be known. In some types the actual adjustment takes place immediately adjacent to the adjustment member—wedge or key—while in others the adjustment actually is on the opposite side of the pin from the wedge or key. In the type shown in Fig. 2 the adjustment and its effect are both on the same side of the pin, therefore after the wedge has been pulled to its limit in taking up wear, the rod is longer to the extent of the wear on the end brass, or about one-half of the total wear, so that a liner put in at *D* equal in thickness to the wear on that brass would restore the pin to its original position; but if one is put in to the full thickness of the wedge advance or all of the wear, it will shorten the rod or shift the pin toward the wedge an amount equal to the wear on that brass, but by the time the wedge

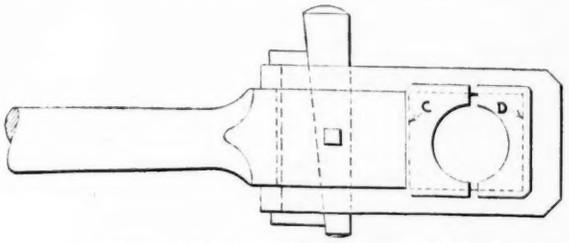


FIG. 4. KEYING UP EFFECT OPPOSITE TO THE CASE OF FIGS. 2 AND 3

is down again the pin will be back in its original position, assuming always that the wear is equal on both brasses. If then, when the wedge is down the second time, it is simply raised and a liner is put in at *C*, the original position is maintained for the time being, because a certain amount has been worn off each brass and a liner put back of each one to offset the wear and the wedge is up, ready for another cycle. The same is true of a stub end of the type shown in Fig. 3.

In the case of a stub end made as shown in Fig. 4, the conditions are different. While the gib and key are on the same side of the pin as in the other two, the adjustment or effect of driving the key is on the opposite side of the pin, and as wear takes place, and when the key is all the way down, the rod is shorter to the extent of the wear on the inside brass. To duplicate the action or process described in connection with Figs. 2 and 3 the first liner should be put at *C* and the second one at *D*.

In either or any case when the slack is all actually taken up, whether by wedge, key or liner at a point between the two pins the rod is lengthened, and if taken up on the opposite side of the pin the rod is shortened. Therefore the wear must be taken up on both sides, by some means, in order to keep the rod length the same.

Making Temperature Trip the Circuit-Breaker

The oldest form of overload protection is electromagnetic, cutting off the current if it reaches a value deemed dangerous. The fact that most electrical apparatus can withstand momentary overloads without danger has gradually led operators to push up the current values at which electromagnetic protective devices will operate, or to dispense with them entirely, rather than undergo the inconvenience of having them disconnect the machinery on momentary peaks.

A method of visual protection on the basis of temperature was the next step. Exploring coils were built into the apparatus and used to indicate the temperature of hot spots by means of electrical instruments.

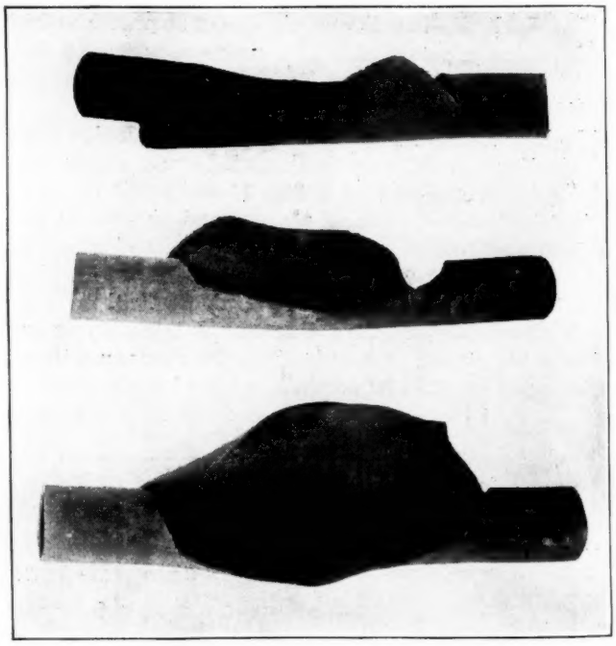
The latest step is a relay, built by the Westinghouse Electric and Manufacturing Co., which automatically trips the circuit-breaker when the temperature reaches the danger point under excessive current. It may be used to protect any alternating-current apparatus from excessive heating if the apparatus is so arranged that exploring coils can be installed.

The relay is intended to protect apparatus against overheating from sustained overloads. To afford this protection with the least interruption of service the breaker should be tripped through the direct effect of the temperature of the apparatus. The relay should be so arranged that it prevents the breaker from tripping if the overload is of such short duration that the temperature does not rise to a dangerous value; and if the overload persists, the breaker must be tripped out as soon as the temperature rises beyond the critical value. This is accomplished as follows:

This temperature relay operates on the Wheatstone-bridge principle. Two arms of the bridge are copper exploring coils arranged to be placed in the oil or embedded in the windings of the apparatus to be protected, the other two arms are unchanging resistance mounted in the relay. The current for the bridge is supplied by the current transformer connected in the circuit of the apparatus to be protected. The relay has two windings, corresponding to and coöperating to produce torque in a manner similar to the current and voltage coils of a wattmeter. The main winding is a coil operated directly by the current transformer. The auxiliary coils are connected to the Wheatstone-bridge arms similarly to a galvanometer connection, and thus receive current the magnitude and direction of which depends upon the resistance of the search coils. Above a certain temperature the torque of the relay is in the contact direction, and below in the opposite direction. It will thus be noted that in order to close the contact, two predetermined conditions must coexist: excess current and excess temperature. Neither one will separately trip the relay. The construction of the exploring coils will vary, depending on the kind of apparatus with which they are to be used.

One Life Lost When Boiler Tube Burst

On Thursday morning, Aug. 15, at a few minutes after 4 a.m., a tube ruptured in a B. & W. boiler in the Kuhn and Loeb Building, No. 52 William St., New York City. The boiler, rated at 175 hp. and carrying 125 lb., had been retubed in January of this year and appeared to be in first-class condition. It appears that some sort of explosion first blew open the front tube-cap doors. The fireman called the night engineer to the boiler room and he was in the act of closing the doors when the tube let go, deluging the engineer with scalding water and live coals from the furnace. He died at a hospital a few hours afterward. The fireman escaped practically



RUPTURED TUBE FROM A WATER-TUBE BOILER

uninjured. The cause of the failure is not apparent, since the tube was practically new and clear of scale and had no appearance of having been overheated. In view also of the light load at that hour, when only a small per cent. of the steam capacity of the boiler was required, there would be no occasion for forcing the fires, and the splendid record of the engineer during his 14 years or more on the job would seem to guarantee that the boiler had received proper attention. The Globe Indemnity Company carried the insurance on the boiler. It is understood that a chemical analysis of the metal in the tube is to be made.

The illustrations show the extent of the rupture as compared to the diameter of the tube, which is 4 inches

EDITORIALS

The Human Power Plant

IF ONE goes into the power plant, he will note the source of energy of all the factory machines, and he will also observe that there is a difference in the productive power from day to day, according to the conditions under which the plant operates. Under normal conditions the capacity of the plant is taxed to its limit; but today atmospheric conditions may be more favorable, the temperature high, and the generating capacity of the plant is increased according to the favorable conditions. Consequently the speed of the stokers is lowered, the dampers more nearly closed, and there is no difficulty in keeping up steam. The next day the atmospheric conditions may be less favorable. The temperature is ten degrees below zero, the dampers are wide open, the stokers are running full speed and the engineer is frantic in his efforts to keep up steam.

Failure on the part of some in authority to recognize the human power plant in our factory life sometimes leads to friction and disastrous consequences. A man would be more than a perfect specimen of physical manhood if he did not feel less vigorous on some days than on others. In a factory where the conditions are such as to conduce to the best interests of men and master, a workman may enter in the morning feeling in prime condition. Mentally he weighs his duties for the day, and they seem insignificant as he looks at them with the feeling of a strong man about to run a race. Backed up by the energy of a healthy body and guided by a well-poised mind, the work disappears before his skilful hands and when evening is near the day's work has been a record breaker. Will the record be sustained on the morrow? It is not likely, and it would be unreasonable to expect it. There is a possibility of sickness in his family, resulting in a sleepless night, preventing nature from performing its usual recreative function; atmospheric conditions or changes in some other of his environments are sure to affect him more or less. Is more to be expected of him in the matter of endurance than would be expected of the machine he operates?

A horse may trot a mile in two and one-half minutes, but would drop dead early in the contest if an attempt was made to continue the pace for an hour. The speed of the railroad locomotive and the steamship varies according to the conditions under which they move. It is the climax of absurdity to think that because a man can do a certain amount of work in one minute he can do sixty times as much in an hour and six hundred times as much in a day.

A lack of common judgment and diplomacy on the part of one in authority may be illustrated in the following: A manager went into his factory where one of his men was placing the hardware fittings on a cabinet and asked him the time required to do the operation. The man said he did not know exactly, as he had never timed himself. The manager then placed a cabinet on the bench, remarking, "Try this one and we will see," at the same time taking out his watch. The man had the cabinet fitted in three minutes, whereupon the manager remarked: "One cabinet in three minutes, twenty cabinets in an hour, two hundred cabinets a day. I shall want you to do two hundred cabinets a day in the future."

Diplomacy is a wonderful gift. It has its seat in an inborn knowledge of human nature. Education may assist in developing it, but academic training can never take the place of a natural insight into the motives that underlie men's actions. Nowhere in the whole realm of human activity is this innate knowledge more to be desired, or of more value, than in one who has the handling of men in the modern high-tension factory life.

Every man who has had to do with the handling of men knows that no two are of the same disposition, and consequently each requires to be handled just a little differently from the other. There are some who will not be pushed. They are anxious to do a fair day's work for a fair day's pay and willing to see their employer make a reasonable profit out of their labor. There are others whose minds seem to move with snail-like slothfulness, and yet behind the apparently impenetrable cloud of mental density there lies the secret, subtle working of a fox-like brain; men whose minds never travel beyond the present farther than mealtime and payday; men whose highest ambition is to beat the man they work for; men whose sole determination is to do as little work and draw as much pay as possible; and men whose highest ambition is to excel in quality. All these and many more are to be met with in dealing with the vast variety of men.

Where the velvet glove is extended, there must always be inclosed the firm hand of steel. There is a variety of man who mistakes kindness for weakness and attempts to take advantage of it by imposing upon good nature. This sort of individual is rare, however, but when occasion demands, he should be met with unyielding attitude. As an illustration, there was a certain man of the semi-bulldog type, vulgar, coarse and verbose, behind all of which was, what is unusual in a man of this kind, the working of a subtle brain. This man was not performing his duties in a manner at all satisfactory and was setting a bad example for the other workmen. He was called into the office, away from the other men, several times and kindly spoken to. He listened to what was said, promised to do better, and went back to work. But things did not improve. He could be a good workman if he would, and as the works were busy his discharge was not advisable. Something must be done and effectively done to bring him around. His superior walked up to him one day, and in voice loud enough for his fellow-workmen to hear, said: "Jim, I want you to make up your mind to one of two things,

and do it quick. Either settle down to work at once or get out of the shop and make room for someone else. I have tried to take an interest in you. I have called you into the office several times and spoken kindly to you, and each time you promised to do better, only to come back and do worse. The thing has become unbearable, and you must decide right now whether you will settle down to your work, or get out of the place."

The man never said a word in retort. He settled down to work and soon became one of the best workmen. It was learned afterward that each time he was called into the office he went back to his fellow-workmen and said: "The boss tried to call me down, but I soon told him where to get off at."

Happily, men of this sort represent only a small part of the "Human power plant."

Making the Most of Substitutes

A CHEERFUL acceptance of the next best thing to that desired for a given service should be one of the cardinal rules of industrial patriotism under war conditions, assuming that the specified material or product cannot be had. There never was a time when there was so great an incentive to study the markets for substitutes and to strive to meet problems with standard equipment. The demands of the war have forced American manufacturers to do a large amount of development work, to be sure; but this is no time to order special machinery when standard products can be utilized reasonably well in particular cases. There is quite enough for the development engineer and the research man to do in dealing with the imperative needs of the war machine, without working overtime to meet the whims of purchasers whose conditions do not justify the withdrawal of super-brain power from the industrial front.

The war has diverted so much raw material and so many finished products from normal channels that the use of makeshifts is no longer a proper subject for criticism. We must all take what we can get, of course, in solving our individual problems, but that is not the whole story. There is room for the exercise of no small amount of intelligence in casting about for substitutes. Emerson said that there is always a best way of doing things, but often, we may add, there are several second-best courses. In the adaptation of inferior coals to power-plant service in various localities is an excellent example of what the war has forced upon the operating engineer and the industrial establishment ordinarily almost finical in sending out fuel specifications. Again, motor applications have been made in munitions plants and other factories of late which no competent master mechanic or manufacturer's sales representative would have stood for before the war from the efficiency point of view. The point today is to utilize the means at hand to the utmost advantage, and if the cost of so doing exceeds the normal outlay, the practice should not be condemned *a priori*.

In the rush to accomplish a stated industrial object, there need not be blind adoption of the first available means to the desired end. Preliminary study of conditions and resources for meeting them should be made, even though the investigation may be extremely brief. It ought not to take long to "hit the high spots" of readily available plans for meeting even emergency conditions. The cost of equipment, supplies, labor and overhead charges is now bound to be abnormal, no matter what means are selected to meet a given industrial situation; but this does not justify immediate acceptance of the first-offered solution of a problem except in rare instances. By refusing to be stampeded into snap judgments and brash acceptances of initial bids and preliminary substitutions offered, one will go a long way toward realizing the most efficient determination of the case in point, even though the selection of methods may be restricted to a degree hitherto unknown to those in charge of the developments in question.

Second Sight and Horse Sense

THERE are engineers who seem to possess a positively uncanny faculty for locating the sources of trouble in connection with the operation of power-plant machinery. Naturally, when a man gets a reputation for being able to ferret out quickly the reason for the stoppage or the faulty operation of an engine, a pump, or some other piece of apparatus, his services are likely to be rather widely sought by those of his engineering friends who are not able to do such work from their own knowledge or experience.

The manner in which he goes about discovering the seat of the difficulty is usually devoid of flourish or affectation. He comes in, looks over the situation carefully, maybe asks a few questions that may appear quite irrelevant to the unthinking, and after a brief consideration puts his finger on the precise point at which the fault lies. And as he does all this without tearing the machine or apparatus to pieces so as to examine its details, he is popularly credited with the possession of second sight or something equally efficacious.

Maybe the trouble finder tacitly encourages this impression by neglecting to explain the method by which he arrives so unerringly at his conclusions. If he does, he displays only a human liking for prestige. But if he were asked point-blank to explain by what means he was able to achieve so remarkable a result, the chances are that he would attribute it to the power of analysis or logical reasoning, although he might not use those precise terms.

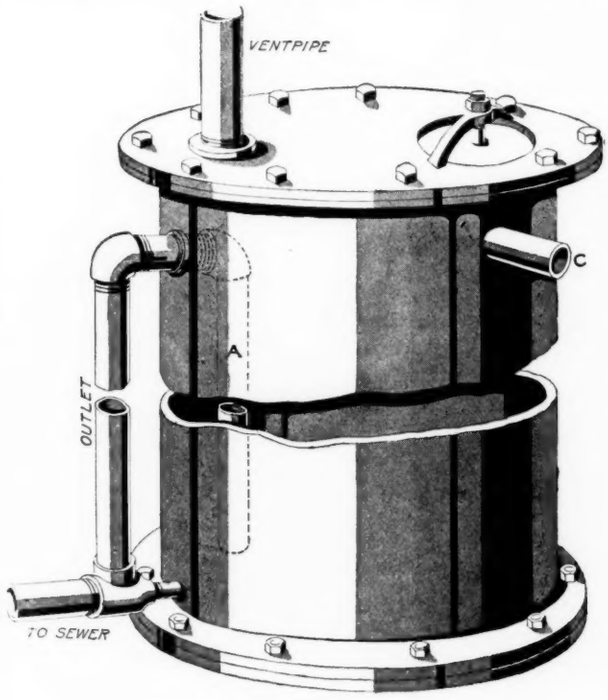
The simple truth is that he makes a diagnosis of the trouble, just as a physician diagnoses the ailment of a patient. There is no legerdemain or hocus-pocus about it. He starts with an understanding of how the apparatus should operate under normal conditions and a knowledge of the symptoms of faulty action. With these as a ground-work, he proceeds to reason back from effect to cause. Oftentimes it is a devious and difficult proceeding, but he continues to eliminate one possible cause after another until he finally isolates the one that lies at the root of the difficulty.

Of course, such a bald exposure of the work of the trouble man snatches away the cloak of mystery that may surround him; but it leaves him still clothed with the garb of a superior intelligence. For the power to make a swift and correct analysis of a power-plant trouble indicates the possession of keen mechanical instinct and thorough training. It is also an evidence of the unusual exercise of horse sense.

CORRESPONDENCE

Blowoff-Tank Pointers

Many city ordinances require that a blowdown tank of approved design be connected between the boiler and the sewer, to prevent a great quantity of steam reaching and injuring the sewer. With a properly designed blowoff tank, the steam and water will be separated to a large extent, and when all the outlet pipes from the tank are of large diameter and free from obstructions, there is little or no pressure on the tank at any time. Accidents have occurred in some cases when the entire diameter of the vent pipe was filled with ice from a small leak in the blowoff valve and the escaping vapor froze in the vent and outlet pipe, so that when the blowoff valve at the boiler was opened, the full boiler pressure was placed on the tank and an explosion resulted. It is therefore good practice to have blowoff tanks strong enough to withstand full boiler pressure; in fact, they should be built along the same lines as the boilers. The illustration shows a design of piping sometimes used, the inlet pipe being located at *C*, and



BOILER BLOWDOWN TANK

the small (1¼-in.) drain outlet connecting the outlet pipe to the bottom of the tank is a direct drain, although it is sometimes omitted, the idea being that the siphon will drain the tank. But I would use this small drain pipe in every case, for when the blowoff valve has been open for a few seconds, the end of the small drain will be submerged and the tank will gradually fill and overflow through *A*. Suitable top and bottom clean-out holes should be provided. J. E. NOBLE.

Portsmouth, Ont., Canada.

Keeping Log Sheets Clean

In most plants where the log sheet is made up by the operating engineer or fireman, it is quite a problem to keep the sheets fairly clean so that they can be easily read and filed away in good condition. Where frequent entries are made and the operators are engaged in work resulting in dirty and greasy hands, the log papers can be kept reasonably clean by using a piece of transparent celluloid as a protector. The celluloid guard can be made as desired with a cut-out section or slot of the size that is necessary to make the entry for one line and moved over any part of the sheet. The celluloid serves as a rest for the oft-begrimed arm or hand and will be found of great assistance in maintaining the papers in a "respectable" state of cleanliness.

Philadelphia, Penn. M. A. SALLER.

Economizers Not Subject to Frequent Failures

I have noticed recent articles under the heading of "Visits of Inspector Brown," in which special attention seems to have been paid to the subject of economizer explosions. When one stops to consider the great number of economizers in service in this country, and the extremely small number of explosions that have occurred, these articles seem to suggest an unnecessary amount of alarm. I doubt if the "Chief" can count an economizer explosion in the United States during the past twenty years for each one of his fingers. The statement is made that the typical economizer explosion is produced by the separation of the tubes and headers, and the explanation of sketches A and B on page 201 in the issue of August 6, leads one to believe that explosions are to be expected only from B-type construction. I have noticed, however, that there have been explosions with both types of tube construction; in fact, the majority of the recent explosions have been type A with tubes tapered in the same direction. Furthermore, in the few cases where economizers have exploded the remaining fragments show that the joints between tubes and headers usually remain intact, whereas the tubes have been broken circumferentially.

No piece of boiler plant equipment is fool proof but, with the proper amount of intelligent care, an economizer in the modern boiler plant is as safe as any other equipment and there is no surer or more definite saving to be made than that made by the use of an economizer. When the "Chief" calls an economizer "a push-nipple cast-iron boiler," he must be referring to a "new breed of the animal," for I have never yet seen nipples used in economizer construction. Evidently the term is used figuratively and foolishly. R. T. FORBES.

East Orange, N. J.

It is with regret that we note that your paper will lend itself to the publication of very evidently sneering

remarks concerning a piece of power-plant apparatus which has been manufactured and operated successfully for nearly seventy-five years.

On page 153 in the issue of July 30 an economizer is called "a push-nipple cast-iron boiler usually operated at very high pressures," all of which is obviously false to those who have any comprehension whatever of the subject and we cannot understand your publishing such articles. There is *not* a nipple used in the manufacture of economizers; they are *not* boilers, but feed-water heaters, and are *not usually*, though sometimes operated at high pressures. There is not a case on record of an explosion of an economizer when operated at what we consider "high pressures" these days.

W. E. REVERE,
Gen. Sales Manager,
New York. Green Fuel Economizer Co.

Supporting Effect of Boiler Heads

I was surprised to note the criticism in the July 30 issue of Mr. Macdonald's article on "Supporting Effect of Boiler Heads" as his treatment of the subject was mechanically correct and furthermore exactly in accordance with the provisions of the A. S. M. E. Code.

The latter part of the third paragraph in Mr. Gauss' article is misleading in stating that "cylindrical fireboxes of vertical boilers must be stayed as flat surfaces only when said fireboxes exceed 38 in. in diameter." Par. 240 in the Code covering this point is as follows: "A plain cylindrical furnace exceeding 38 in. in diameter shall be stayed in accordance with the rules governing flat surfaces." It will be noted that the above paragraph does not specify "only" furnaces exceeding 38 in. but applies to all exceeding this dimension. Par. 212 gives the requirements for smaller furnaces which are to be stayed.

As regards determining the safe allowable pressure on a cylindrical furnace his method is plainly contrary to the Code. Par. 212 states as follows: "An internal cylindrical furnace which requires staying shall be stayed as a flat surface as indicated in Table 3." The furnace which he has taken as an example, according to his figures, does not have sufficient strength to resist a pressure of 125 lb. without stays. Consequently, in order to comply with the above Code requirement (Par. 212) it should be stayed as a flat surface, in accordance with Table 3, which specifies, for $\frac{5}{16}$-in. plate at 125 lb. pressure, the maximum permissible pitch of stay-bolts to be $4\frac{3}{4}$ in. This demonstrates that Mr. Gauss' boiler with stay-bolts pitched approximately 8 in. would fall far short of meeting the Code requirements. As a further proof that Mr. Macdonald's demonstration is correct I would refer Mr. Gauss to the American Society of Mechanical Engineers' Interpretations of the Boiler Code Committee, Cases 57 and 113 (a), as follows:

Case 57. The furnace of a vertical fire-tube boiler need not be stayed if the maximum allowable working pressure computed by Par. 239 of the Code is equal to or in excess of the pressure under which the boiler is to be operated. If the pressure computed by Par. 239 is less than that at which the boiler is to be operated, the furnace should be fully stayed in accordance with the rules for flat surfaces. Furnace sheets should in all cases be $\frac{5}{16}$ in. thick or over.

Case 113 (a). An internal cylindrical furnace which requires staying shall be stayed as a flat surface, and no value will be given the furnace sheet due to its curvature, in accord with Par. 212.

Par. 239 referred to in Case 57 contains the formulas for computing the allowed pressure on unstayed circular furnaces, which Mr. Gauss has quoted.

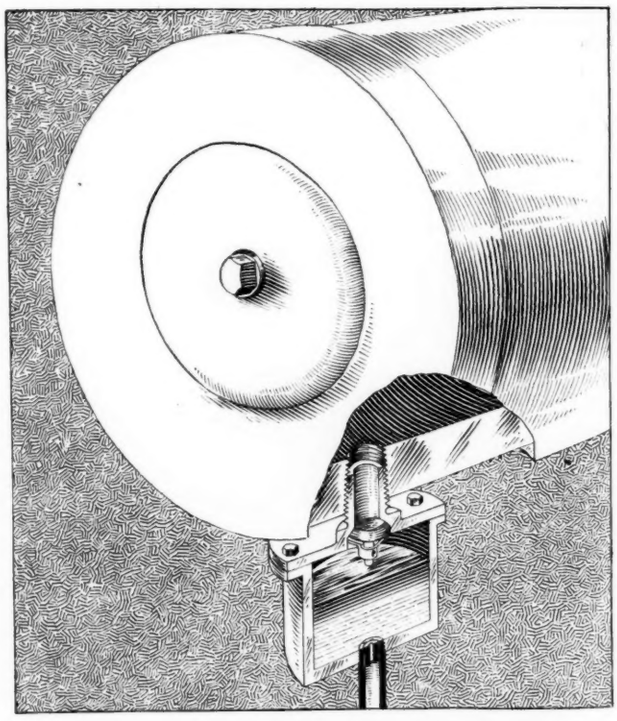
The authoritative references quoted above clearly demonstrate that it is not permissible to add the collapsing resistance of plates to strength of staybolts when calculating the safe working pressure on staybolted cylindrical furnaces. The same principle applies to each of the several types of stayed surfaces, namely, the construction is assumed rigid to such an extent that the entire load on plates is transmitted directly to the stays, which must be designed to carry the total load.

Baltimore, Md. D. R. HUNT.

Ridding Engine Cylinder of Water

Following is a suggestion for reducing the steam and fuel consumption in steam engines. Instead of the ordinary cylinder drain cocks, substitute a small reservoir with a hole for the continuous discharge of condensed water and possibly a small amount of steam. The size of the hole should be just the right size to allow the water to escape without losing too much steam.

In working conditions some of the steam admitted in the cylinder, condenses against the surface of the piston



CONTINUOUS DRAIN FOR ENGINE CYLINDER

at each stroke and this water, evaporating during the exhaust, cools off the piston and other surfaces and increases the condensation in the following stroke. This condensed steam is not only completely lost as power but its cooling effect in reëvaporating increases the condensation at the next admission. A large part of this loss could easily be overcome by placing the steam chest below instead of above the cylinder or by the use of the

attachment illustrated which would let the water pass into the reservoir and out through the small hole, removing it entirely from the cylinder.

In two experiments by the Association of Boiler Inspectors of Belgium considerable saving resulted. The first experiment was on a direct-acting steam pump, with the steam chest above the cylinder. The pump consumed much less steam per horsepower when the two drain cocks were left slightly open to get rid of the water and even some steam was allowed to escape.

The second experiment was on a stationary engine, without cylinder drains, with the steam chest over the cylinder. When operating condensing the engine used more steam per horsepower than while working noncondensing, contrary to what should happen.

In both cases, the water when left in the cylinder evaporated (evaporated more quickly in a vacuum), cooling off the cylinder walls, with the consequent loss. I have made several similar tests with our own engines with the same results in all cases. H. BOLLINCKX.

Geneva, Switzerland.

Soldering Wire Joints

In the issue of July 30, page 173, Mr. Noble questions the efficiency of soft solder as a medium for making joints in electrical wiring. He states that owing to the high resistance of soft solder (10 to 12 times that of copper), it is inadvisable to use more solder than just enough to cover the joint, but since the resistance of a conductor is inversely proportional to the cross-section, it is hard to see how an excess of solder can have any detrimental effect, considering that increasing the amount of solder increases the contact area. Suppose for example we wish to tap a branch of No. 10 wire off a circuit also of No. 10 wire, and we make only one turn of the branch wire around the feeder, and solder it. I think it would be hard to make less contact than about 3 times the cross-section of a No. 10 wire. It has been my experience that joints like this are usually made with 4 to 5 turns no matter how inexperienced or careless the workman may be. This would give a contact area of 12 to 15 times the cross-sectional area of the wire, and if the joint is well soldered it may have less resistance than the wire itself.

I have noticed that many men will wrap the turns tightly against each other when making a joint, which in my opinion is bad practice, as there is less chance for the solder to flow than where the turns are slightly separated; furthermore, separating the turns will increase the contact area of the joint.

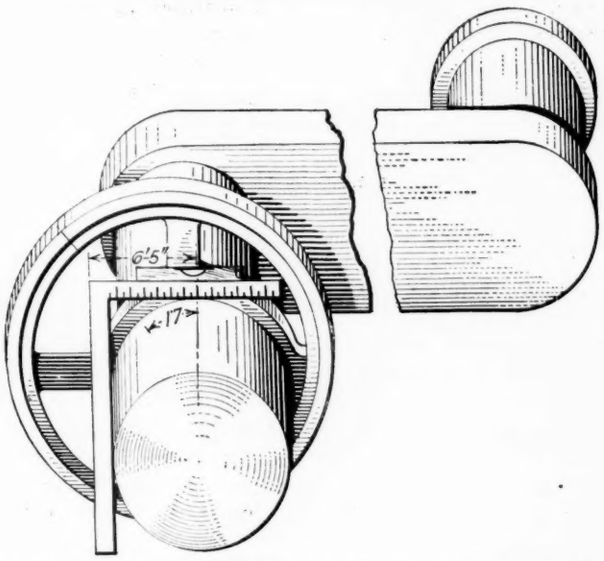
I have never seen any mention in *Power* of the value of tinfoil when making connections on electrical apparatus. Where I am employed we have a 100-hp. motor-generator set which at times is called upon to carry a 50 per cent. overload for several hours. This at one time caused the lugs where the cables are connected to the machine to heat up until the solder melted out of them. After resoldering we placed a sheet of tinfoil between the lug and stud and since then have had no trouble from heating. FRANK GARTMANN.

Waukesha, Wis.

[The suggestion in the original letter was "to get as good a copper contact as possible before soldering." In other words, to avoid interposing solder between the copper conductors.—Editor.]

Measuring the Angle of Advance of an Eccentric

Supplementing the method described in reply to L. B., beginning at the foot of the first column on page 65, July 9, the following is suggested—the marks and measurements being made on the shaft instead of on the wheel as described. The first thing is to find the diameter of the shaft, in this case we will take a 13-in. shaft, then find the circumference by multiplying by 3.1416 = 40.8, which equals 360 degrees; the problem is to find the number of degrees the eccentric is ahead of a vertical line passing through the center of the shaft when



FINDING THE ADVANCE OF AN ECCENTRIC IN DEGREES

the engine is on a center. Place a steel square with one blade against the shaft and the other blade horizontally over the shaft, by the use of a level on the blade, and in this way find the center, one-half the diameter of the shaft. Put a fine scratch mark at that point which is the center or 90 degrees ahead of the crank. The difference between this mark and one opposite the center of the throw of the eccentric, measured with a steel tape, gives the advance of the eccentric which we will say was 1.7 in. This distance divided into the whole circumference goes 24 times (40.8 ÷ 1.7 = 24), so the eccentric is advanced $\frac{1}{24}$ of 360 deg., or 360 ÷ 24 = 15 deg.

Chicago, Ill. WILLIAM HENDREY.

Why Does the Water Disappear?

A question that has puzzled engineers more or less is, Where does the water go to when a boiler is under banked fires with the pressure maintained but no steam being drawn from the boiler? For instance, a boiler may be held in reserve, the steam pressure remaining at the usual point for several hours, but in some cases it will be found necessary to introduce more water. Apparently all of the valves on the piping attached to the boiler are closed and steam-tight, and to all appearances no steam is getting away, yet there may be a constant lowering of the water level.

Although such action may not occur in every plant, it has often been brought to the notice of engineers; but as a general thing they have not given the subject consideration or taken steps to discover the reason for

the loss. It requires coal to heat water, and under the present fuel situation it would seem that here is a circumstance that engineers could investigate with profit, although perhaps the loss of fuel in such cases would be small and hardly noticeable in the total coal cost of operation. It is evident, however, that fuel can be wasted in this manner, and frequently much more rapidly than one would suppose.

In the heated air of a boiler room it is usually impossible to detect a very small leak, but every engineer knows that the boiler room that does not have the sound of escaping steam is a novelty. These leaks would account for some of the water loss mentioned.

That all steam-valve stems are not tight can be proved. If windows and doors are opened in the boiler room so as to cool the air, it will be seen that vapor is escaping from the valve stems but in such small quantities as not to show unless it begins to condense. Of course a number of such leaks would amount to several pounds of water in the course of 24 hours, and would account for a large percentage of the total amount escaping from the boiler.

As 1 cu.ft. of steam at atmospheric pressure weigh about ½ oz., it would seems that for every 32 cu.ft. of steam escaping there would be 1 lb. less water in the boiler. It does not take long for this volume of steam to escape, even without making sufficient noise to be heard by the operator at a short distance from the valve. This is because the steam in issuing from the stuffing-box on the valve stem has to pass through the packing, and escapes at a very low velocity, and it is only by lowering the temperature of the boiler room that steam is visible.

Another source of leakage is from the blowoff valve. Most engineers content themselves with the assumption that the valve is tight unless the blowoff pipe becomes so hot that they cannot hold their hands on it. One way of determining whether the blowoff valve is leaking slightly is to disconnect the pipe and, in cold weather, lower the temperature of the boiler room, when the steam will condense and the vapor will become visible. Under ordinary conditions, however, the leakage is such that drops will be seen, and it does not take long for a gallon of water to pass from the boiler through this source of leakage. This loss in addition to the escape of steam from the valve stuffing-boxes will undoubtedly represent a large percentage of the total.

When a boiler loses water under the conditions mentioned, the engineer can be sure that it is because of a number of leaks so small and noiseless that they do not attract his attention, and are therefore allowed to continue.

E. W. KING.

Boston, Mass.

Smokeless Furnaces

For some years now, owing to measures taken to abate the smoke nuisance, and to produce better combustion, the question of burning coal without smoke has been before engineers, but the aim of some has only been to so equip their boiler furnaces as to prevent smoke from issuing from the chimneys. Many devices have been installed, and there is a division of opinion regarding the merits of various smoke-preventing furnaces.

When this question is brought to the attention of some they immediately have a vision of expensive design of furnace and some sort of mechanical stoker; on the other hand, others are satisfied with the use of checkered brickwork in the combustion chamber, hollow bridge-walls, brick arches and other means of preventing smoke formation. Experience has shown that such devices serve their purpose fairly well if light firing can be maintained and the steam pressure kept at the desired point. In most manufacturing concerns, however, light firing cannot be maintained, and the remedy would seem to be the installation of mechanically operated furnaces or the aid of an arrangement of steam jets. In these two methods steam must be used, either to drive a stoker engine or to provide steam for the jets. Aside from obtaining smokeless combustion, the question that should concern the engineer is whether he can save any money by their use. If the apparatus when in use will save interest on the first cost, and reduce the cost of maintenance, if any, over older or former methods, most would call it a safe investment, and the question that interests the engineer is, Will a smoke-preventing furnace do this?

In most cases it may be proved that it will do so, but there are probably cases where the success of the apparatus will depend largely upon the steam user. Under ordinary working conditions a steam boiler that is properly installed, operated and well cared for generally, will last for about 15 years before expensive repairs are necessary. If an unskilled man has it in charge it may be ruined inside of a week. The operation of a stoker is also in the hands of the user, and if it is abused and neglected the repair bill will necessarily be excessive.

There is a difference between abating smoke by the use of an automatic stoker and devices that use steam and air jets, hollow bridge-walls, checkered brickwork, etc., although the latter devices when properly applied and operated do good work and all that can be expected of them. Abating smoke is one thing, but saving fuel is another and a very different thing to accomplish. From the point of economy it would seem that in large plants the smoke abatement should be coupled with fuel economy, and the construction of the furnace so carried out that these two results can be obtained in the one and same operation, thus killing two birds with one stone.

J. F. MANLEY.

Baltimore, Md.

Corrections

On page 212 in the issue of Aug. 6 under the group picture of the convention committee of the National Association of Stationary Engineers, the names of George H. Coulthard and Theodore Nielander should be reversed from the order given—Mr. Nielander is the second from the left and Mr. Coulthard is third.

In the example worked out at the top of page 83 in the issue of July 16 the total length of pipe should have been stated as 1500 ft. instead of 2000 as given. It will be observed that 15 is used throughout the problem instead of 20, as would have been the case for a 2000 ft. run.

INQUIRIES OF GENERAL INTEREST

Thickened Ends of Connecting-rod Straps—Why are connecting-rod straps heavier at the open ends? W. L.

The open ends are made of larger cross-section to obtain greater stiffness against bending and to compensate for material removed by the mortise made through the strap for receiving the gib and the key.

Prevention of Hammer in Boiler-Feed Line—What is the best way to stop water-hammer in a boiler-feed line to eight 150-hp. boilers? S. A. B.

Provide good-sized air chambers in the line on the discharge side of the pump and at the end of the line. Air chambers are, of course, worthless as shock absorbers if they become filled with water, and to insure good service they should be provided with glass gages for determining at sight whether they need draining and should be provided with suitable fittings and connections for the purpose.

Representing Average Temperature on Circular Chart—How can an arc be located and drawn on a circular temperature chart that will represent an average of temperatures that have been recorded? F. W. C.

Take the average of values that have been recorded at short, equal intervals of time, and locate a point on the chart at a distance from the center to correspond with the average value when measured by the values of scale circles of the chart. Then with a compass centered at the center of the chart, strike a circle through the located point to represent the average of temperatures recorded.

Steam Required To Melt Ice—How many pounds of steam at 100 lb. absolute pressure would be required to melt 20 lb. of ice at 24 deg. F.? J. H.

The specific heat of ice is 0.504 and to heat 20 lb. of ice from 24 deg. F. to 32 deg. F. would require $20 \times (32 - 24) \times 0.504 = 80.64$ B.t.u. Upon reaching 32 deg., before the ice would be melted it would require the latent heat of fusion, or 144 B.t.u. per pound; that would require $20 \times 144 = 2880$ B.t.u. and the total heat required would be $2880 + 80.64 = 2960.64$ B.t.u. A pound of steam at 100 lb. absolute contains 1186.3 B.t.u. above 32 deg. F. and to melt the ice would require $2960.64 \div 1186.3 = 2.49$ lb. of the steam.

Increasing Size of Suction Line Reduces Loss of Pressure—The size of suction connection on a boiler-feed pump is 2 in., and water at 208 deg. F. is supplied from an open heater under 8 ft. head. Would the pump suction be supplied at greater pressure by increasing the size of the suction pipe to 4 in. from the pump back to the heater? S. S.

The static or standing pressure would be the same for any size of pipe, but when water is moving through the suction pipe, as when the pump is running, for a given number of gallons flowing per minute, the loss of head from friction would be reduced by increasing the size of the whole or any part of the suction pipe.

Pitting and Corrosion from Apparently Good Feed Water—The feed water used in our boilers is considered to be of good quality for general purposes and is very free from scale-forming impurities, but the boilers appear to be affected by pitting and corrosion. What would be the cause and remedy? W. B. C.

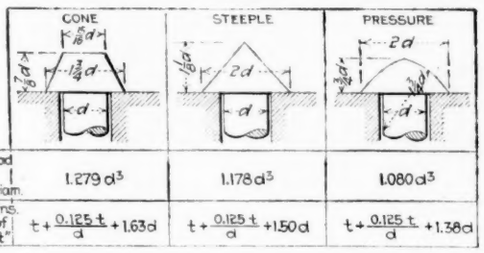
For intelligent treatment the character of the water should be ascertained by analysis. It is likely that the water is highly aerated or contains an acid in sufficient proportion to cause corrosion. A small quantity of soda ash placed in the boilers may be beneficial. Another method of arresting corrosion would be to place only enough lime in the boilers to form a whitewash coating so thin that it would not endanger burning out of the boilers or be seriously detrimental to economy.

Effect of Higher Steam Pressure in Steam-Jacketed Kettle—Will steam supplied to a steam-jacketed kettle at 80 lb. pressure raise water to the boiling point and cause it to boil more rapidly than if the steam is at 40 lb. pressure? S. D. W.

If the jacket is drained of condensate as fast as it is formed, and the steam pressure is maintained at 80 lb. gage, water contained by the kettle will be raised to the boiling point in less time and will boil more rapidly than by use of steam at 40 lb. This must follow from the fact that the temperature of steam at 80 lb. gage is 324.1 deg. F while the temperature of steam at 40 lb. gage is 287.1 deg. F. and the rate of transfer of heat would be more rapid the greater the difference between the temperature of the jacket steam and the temperature of the water contained by the kettle.

Proportions of Boiler-Rivet Heads—What proportion of stock is taken for forming boiler-rivet heads? G. W. F.

The approximate proportion of rivet heads most commonly employed in boiler work and volume and length of shank required for the heads are shown in the sketch. The


CONE
STEEPLE
PRESSURE
Volume of one Head in Terms of undriven Shank Diam.
1.279 d³
1.178 d³
1.080 d³
Length of Shank, ins. to join Plates of Total thickness = t"
t + 0.125 t / d + 1.63 d
t + 0.125 t / d + 1.50 d
t + 0.125 t / d + 1.38 d

cone head is the usual one pressed on rivets as furnished by manufacturers. The steeple head is the usual form of hand-driven rivet head and the pressure head shown is the type most commonly used in machine riveting. The sketch shows the approximate proportion of head, volume of head in terms of undriven shank diameter, and length of rivet shank required for joining plates of total thickness t, allowing for the volume necessary to fill the clearance $\frac{1}{32}$ in. around the rivet and also for forming the head.

Steam Line in Mine Shaft—We have several electric mine pumps that are operated at a depth of about 1600 ft. and steam pumps for stand-by service. To prevent trouble from leaks due to expansion and contraction, steam is left all of the time on a 4-in. steam line running down the shaft, and there is considerable loss from condensation. If the line is put in properly, could not the steam be turned on and off frequently without any trouble from leakage? S. C. G.

Success in the prevention of leaks in the line from expansion and contraction, resulting from changes of pressure and temperature, would depend mainly on the arangement of anchorages, supports, kind of expansion joint and skillfulness with which the expansion joints are set and maintained. A break in such a steam line is likely to be attended by very serious results, compared with which a large waste of steam by condensation would be trifling, especially if the line has a nonconducting covering. More or less trouble is likely to arise from frequent turning on and off of steam and with most any system of anchorages and expansion joints greater safety is to be obtained with a constant pressure and temperature. If covering is used it would be advisable to leave all joints and fittings uncovered and otherwise exposed so they may be readily inspected.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. Editor.]

Boiler Furnaces and Boiler-Furnace Design*

By Dr. D. S. JACOBUS

ONLY a comparatively short time ago, say 10 or 15 years, there were few stationary boilers operated under steady load conditions above a capacity of 125 or 150 per cent. of the so-called rating, or 200 per cent. of rating under peak-load conditions. As you all know, boilers are now ofter run at higher capacities than this and what was considered to be a high capacity only a comparatively short time ago is now considered more in the light of ordinary everyday practice.

In an endeavor to obtain high capacities there was a limiting feature in many cases in that, in attempting to run a boiler beyond a certain capacity, the furnace would give out. This same limit still holds in most cases, and in boilers properly designed for high capacities the capacity obtainable is limited only by the amount of fuel that can be burned, which in turn is governed by the stoker and furnace conditions. With a properly designed and set boiler and clean feed water, the first thing that is likely to give difficulty in running at high capacities is the furnace and not the boiler, and my talk will be on the development of furnace design, after which, if you gentlemen wish to ask any questions along other lines, I will be pleased to respond to the best of my ability.

Height of Boiler Above Grate

When I first went with the Babcock & Wilcox Co. the average setting height for the Babcock & Wilcox boilers, or the distance from the floor line to the lower ends of the uptake headers, was from 6 to 9 ft. A great many had the idea—and among them were some of our very best engineers—that if the boiler was set too high above the grate, or above the stokers, there would be a loss of efficiency. With the development of higher capacities we set the boilers higher and higher, and for stoker firing these boilers now have a setting height of from 10 to 14 ft. The larger furnaces secured by increasing the setting height give better combustion conditions and minimize the tube difficulties, but these larger furnaces lead to more difficulty in maintaining the brickwork. In large furnaces of the sort run at the highest ratings we often approach the limit of temperature where the bricks will become plastic, and this has led to principles in furnace design that must be understood in order to secure a successful installation.

In the first place enough draft must be provided to draw the products of combustion through the furnace and provide a draft suction under all conditions within the setting. With a forced-draft stoker we are able to burn a greater amount of coal with a given stack capacity than with natural draft. When the modern underfeed stokers first came out, the claim was often made that as high a stack was not needed as with natural draft. It is a mistake to cut down the size of the stack unless the equivalent draft suction is obtained by means of an induced-draft fan, because if a forced-draft stoker is operated beyond a point where the gases can be properly carried off, the back pressure within the setting will cause the gases to leach outward through the setting, with the result that the furnace brickwork cannot be properly maintained. The same size stacks are now being used with underfeed stokers that were previously used with natural draft, because the tendency is to secure a greater capacity than with natural draft, and the full-size stack is necessary to draw the gases through the boiler and prevent a back pressure within the furnace. A fundamental principle for ordinary boiler settings is that some suction, if it is equivalent to, say, only a twentieth of an inch water head, should exist within all points of the setting, irrespective of how hard the boiler may be driven.

The next principle to observe is to avoid a construction in which the brickwork is heated on both sides when under too great a stress. An arch that is heated on both sides under severe furnace conditions may give trouble. The same applies even to a vertical wall which is heated to an extremely high temperature on both sides.

Localized Action of Flame on Walls

Another feature that should be avoided is a torch-like action of the flames on the walls. If a forced-draft stoker is improperly operated, the formation of large clinker and the bridging over of the top of the fire above the clinker may cause a torch of flame to be projected against the front wall of the setting, which may heat the wall locally to a point that will cause the bricks to become plastic, and in turn lead to erosion and final collapse of the wall. Again, the side walls as well as the front walls will sometimes be eroded opposite the fuel bed, this action apparently occurring to a greater extent with some classes of fuels than with others, and all these conditions must be contended with in building a furnace for high-capacity work.

After a problem is solved, as a rule it looks quite easy, but the man who first undertakes a task and puts it through deserves a great deal of credit. Some of the biggest furnaces we have constructed are in connection with the Stirling boilers that Alex. Dow installed at Detroit. When these boilers were first started, there was considerable difficulty with the brickwork, especially in the holding up of the side walls. In the first boilers a bridge-wall was placed in the middle of the furnace. The side walls opposite the furnace were of a great height, the distance from the fuel bed at the bottom of the furnace to the top of the furnace being about 30 ft. A double line of stokers was employed, with the stoker hoppers placed about 20 ft. apart.

At first the side walls failed through their bulging inward toward the furnace. Buttress-like walls were built from the top of the ends of the bridge-wall for bracing the side walls, but these became plastic and came down with the side walls. Other methods were tried until the walls were held up successfully, and it might now seem that the holding up of these walls is a simple matter, and yet when one knows what was gone through with to secure success it emphasizes the fact that a development of the sort usually requires most painstaking work in overcoming difficulties that develop in actual service. The instance I have cited of the Detroit boilers is typical of the way in which the art of furnace construction has been developed, and it is only by a long painstaking experience, where the difficulties have little by little been worked out, that we are able to build and maintain the larger furnaces that are now employed.

Furnace Must Give Economical Combustion

In addition to obtaining a furnace that will stand up, we must secure an economical furnace, or one that will give proper combustion conditions. As we advance, economy is assuming more and more importance. The average user of a boiler in the past, aside from the operators of large power plants, has not as a rule given serious consideration to a small difference in economy, but eventually more and more stress will be laid on this feature. The movement to save coal that has been started by the Fuel Administration, the detail work of which is being actively pushed by D. M. Myers, is bound to bear its fruit, aside from the fact that the increased cost of coal makes it imperative on the part of the boiler user to save all that he can. Tests made by the week or the month, such as the tests made in most power stations where all of the data are kept continuously, are by far the most useful. We all know what misleading results may come from a short run. The practice is growing of obtaining continuous records of boiler economy, and as this practice becomes more general, more and more attention will be given to securing the best results. In designing a furnace for economy we should therefore have in mind securing the best results under operating

*Address delivered before the American Boiler Manufacturers' Association in convention at Philadelphia, June 17, 1918.

conditions rather than the results that may be shown in any short tests.

Let us start with a coal-fired furnace In a coal-fired furnace we have in the first place to watch out for excess air. Excess air is not all, as we must also watch out for carbon monoxide. Unfortunately, there is often an error in determining the amount of carbon monoxide, and the error is usually on the side which indicates less carbon monoxide than is actually present. The analyses may indicate, say, 12½ to 13½ per cent. CO_2, or even up to 14 per cent., and no CO or a trace of CO. A short test may be made in which there is every chance that the coal may not be accurately balanced at the beginning and end, as it is human nature for the fireman to make sure that he does not lose at the start or the finish. On working up such a test a heat balance might bear out test results showing a high capacity and high efficiency, whereas if the CO had been accurately determined, instead of a trace of CO there might have been, say, half of one per cent. in the gases, or even more, and had the correct flue-gas analyses been employed, the heat balance would have shown that the results were in error. Te secure economical results the combined arrangement of stokers and furnaces should allow 13½ or 14 per cent. of CO_2 to be carried with only a trace of CO when the CO is determined by an exact analysis. In some furnaces only 10 or 11 per cent. of CO_2 can be carried without the presence of CO, and on endeavoring to cut down the excess air to obtain a higher percentage of CO_2 the percentage of CO will increase to a point that would cause a falling off in the economy.

Admission of Air Above the Fire

Under certain conditions it may be necessary to admit air above the fire. In burning coal it appears to be impossible to have an even fire bed and from every part of the fire bed secure a uniform and economical analysis. Some parts of the fire bed will give off volatile gases and CO and other parts, with the stokers as we have them today, will allow excess air to enter the furnace. We therefore have to employ a furnace that has a sufficient volume and such a shape that it will cause the combustible gases to mingle with the excess air. To illustrate what happens in a furnace, I will again refer to the Stirling boilers at Detroit. It so happened that the coal selected for the tests would slide down at times on the Roney stokers and cover the dump plates to such a depth that there would be a high CO component. We installed a 12-in. pipe in the bridge-wall at the center of the furnace with holes in the pipe at intervals along its length, and left openings in the bridge-wall opposite each of the holes in the pipe with the idea of admitting air into the furnace above the fuel bed. Air was available under a forced blast of from 3 to 4 in. water pressure, and this was piped up and arranged with a damper so that any desired amount of air could be admitted to the 12-in. pipe. When air was admitted, with considerable CO, a flame was projected from each one of the openings and on looking into the furnace the air appeared to burn like a number of gas jets all the way along the bridge-wall. Another thing that happened that we did not expect when we installed the pipe and openings in the bridge-wall was that the slag ran down and made a hood over each of the openings and finally blew the air downward over the top of the unburned coal on the dumping plates, thereby serving a most useful function in burning out the combustible matter from the coal and refuse which rested on the dumping plates. After we installed the pipe, we could secure good flue-gas analyses and high efficiencies, whereas before we put the pipe in we were unsuccessful in doing this when we ran into difficulty with the coal sliding down from the stokers onto the dumping plates.

After we finished the tests with the coal selected for the majority of the tests, we made supplemental tests with another coal of the same general class that we used for the majority of the tests, and with this coal we were able to secure good gas analyses and high efficiencies without admitting air directly to the furnace. This was on account of the fact that the coal did not cause trouble through sliding down from the stokers. That one coal should require the admission of air above the fuel bed and the other not, shows to what a great extent a variation in the fuel may affect the furnace efficiency and the number of elements that one must take into account in designing a furnace.

Thorough Mixing of Gases in Furnace

I have cited the case of admitting air to show that there is much more in the proper design of a furnace than simply holding the bricks in place. There must be some way of mingling the unburnt gases which come from one part of the fire with the excess air from another part of the fire. With a furnace such as was used at Detroit, having large volume and long path of flame travel, any air from one part of the fire is mingled with the unburned gases from another part, and the tests which we made, and which were published by the A. S. M. E., show what can be obtained in the way of flue-gas analyses and economies. The individual records of the flue-gas analyses were more striking than the average results which were published, because analysis after analysis was secured with over 14 per cent. of CO_2 with no CO. We might then get an analysis with, say, 16 per cent. of CO_2 and 1½ per cent. of CO, and the 1½ per cent. would lead to the presence of a material amount of CO in the average analysis so that the average analysis did not appear as striking as many of the individual analyses.

Another feature in furnace economy is the burning out of the ash. Any loss of carbon in the ash counts directly against the efficiency. We must, however, guard against an endeavor to burn out the ash too clean at the expense of having too much excess air. Modern stokers have been developed to a point where with the proper furnace 13½ to 14½ per cent. of CO_2 may be obtained with an average of not over 0.2 per cent. of CO with what is classed as a reasonably clean ash, containing, say, 15 per cent. of carbon.

The success with which powdered coal has been used in connection with the burning of cement and in heating furnaces has caused it to be experimented with as a boiler fuel. Naturally, as the price of coal advances it makes the cost of pulverizing the coal a lesser percentage of the total cost and broadens the field for powdered coal. There are so many features that have to be contended with in burning powdered coal that the general practice, as we all know, is to burn coal by means of stokers, so that I will not deal further with this method except to say that the furnace plays an all-important part and one of the difficulties has been to construct a furnace that will stand up properly.

Atomization of Oil Used for Fuel

Oil fuel is next in importance to coal. In land practice we ordinarily employ steam atomizing burners and furnaces which allow for a natural path of travel of the flames and in which the space for combustion conforms with the natural form of the flames, the air being admitted through checkerwork beneath the flames. In marine work steam cannot be used for atomizing as it would involve the waste of too much steam, which in turn would require too great a quantity of makeup water to be supplied for the boilers. For marine work pressure atomizing burners are therefore employed. Our Government uses oil in the greater part of its war vessels where the very maximum boiler capacity must be secured with a given fuel-storage capacity and boiler-room space. In marine service with oil the furnace volume cannot be made as large as in land service, and this means that a burner must be employed that burns the oil with a short flame. Properly designed pressure atomizing burners, where the oil is atomized through discharging it under a heavy pressure, are especially adaptable for this work.

The quickness of action required in burning oil in marine service reminds me that I should have emphasized the fact that the flue-gas analyses and percentages of carbon in the ash for coal burning are not the only features that govern the efficiency With either coal or oil, all, or certainly the greater part, of the combustion should be completed within the furnace if efficiency is not to be sacrificed. Fuel burned in the furnace before the gas hits the boiler tubes develops heat which is available for absorption by all of the boiler tubes. In a properly designed arrangement of stoker and

furnace there may be delayed combustion, which will count against the efficiency, whereas the flue-gas analyses may be the same as for a properly designed furnace where there is no delayed combustion. One cannot, therefore, make an intelligent guarantee based simply on the flue-gas analyses and the percentage of carbon in the ash; the character of the furnace and type of stoker must be known, as well as the grade of fuel which is to be burned.

In burning blast-furnace gas the modern burners effect a thorough mingling of the gas and air, leading to a quick action and shorter flames than in many of the older burners. A difficulty often experienced with the older types of burners came through a "lancing" action of the air and the gases which led to secondary combustion within the setting; in fact, with improper operation the secondary combustion would extend as far as the uptake. In constructing a furnace for blast-furnace gas there should be an ample furnace volume and a long path of travel.

Another fuel is wood—either wet or dry. The wood burned at sawmills is usually wet. Wet wood, as we all know, is best burned in an extension furnace where there is a large amount of radiating surface of hot brickwork to dry out the wood. A great many do not appreciate the fact that if you have sawdust with 50 per cent. of moisture in it, each pound of dry wood has one pound of water to evaporate before it can be burned. If there is 66 per cent. of moisture, each pound of dry wood has two pounds of water to evaporate before it can burn. Any moisture above 50 per cent.—and in some cases the moisture may exceed 60 per cent.—therefore leads to a considerable handicap in burning the wood, and the importance of a proper furnace arrangement can readily be appreciated.

I have talked much at random in regard to the general problem of furnace construction, and I shall now be pleased to answer any specific questions that may be asked.

Discussion by Members

THE CHAIR: I would like to ask you where the heat takes the greatest effect on the wall of boilers of the design which you mentioned?

DR. JACOBUS: Where they had the most trouble was with the side walls, which bulged inward toward the fire. This is an action that often occurs with large hot furnace walls. Apparently it comes from expansion and contraction, which cause the wall to bulge inward toward the furnace. Some of the walls at Detroit were laid up of solid firebrick in which were placed iron pieces which were tied back to an outer framework. These walls stood up fairly well. Finally, a panel in the form of a camber was placed in the side walls.

A MEMBER: How thick were those walls?

DR. JACOBUS: The walls, which were tied back with iron pieces, were about 22½ in. They were laid up with whole firebrick. Of course the exact size depends on the size of the brick.

MR. BACH: You touched on one point that I think is of great importance to water-tube boiler manufacturers, particularly in the matter of guarantees as to capacity. I had an experience with a forced-draft stoker. We put in a 400-hp. boiler that did not give the ratings they had anticipated, and I found they had cut down the stack height we had specified to 40 ft. because the forced-draft stoker man told them none was required. The result was a regular retort condition of the furnace that not only melted down the brickwork but did not give them capacity. The plant was in operation, and had to be kept going, and the only suggestion I could make was to put a steam jet in the stack. Since then I have incorporated in our contracts a clause which says that where certain capacities are demanded, at least so much draft must be provided, even with a forced-draft proposition, because you get a reverberatory retort condition in your furnace and a terrific temperature, but you get no work in the second and third passes of the boiler.

DR. JACOBUS: You are right in specifying the draft required. What happens is this: If there is any pressure at all in the furnace, the tendency is for the hot gases to leach outward through any cracks in the brickwork or setting and, in fact, through the brickwork itself. If there is a suction, the tendency is for the cold air to leach inward and the difference between leaching outward and leaching inward is what makes all the difference between having a lot of trouble and not having it.

A MEMBER: The balanced draft will bring you up to that.

DR. JACOBUS: I have often told the balanced-draft people that they made a mistake in calling it balanced draft. They should call it regulating draft. The draft can be regulated by means of an automatic device to give a certain amount of suction, and in some cases it is advantageous to employ an automatic device of the sort.

A MEMBER: Don't you find it almost impossible to get a given suction and hold it for any length of time under a certain set of conditions?

DR. JACOBUS: It requires close attention, but close attention must be given in properly operating a boiler plant. Of course, if an automatic regulator is employed, this can be set to automatically govern the suction at any given point in the furnace or it might be set to give nearly a balanced pressure at one point and a reasonable amount of suction at every other point. There is one thing certain, and that is that there must be a suction within the furnace; otherwise there will be trouble.

A MEMBER: What would you consider a good suction?

DR. JACOBUS: I would prefer a tenth of an inch rather than anything less.

MR. BACH: I have one more question. I would like to have an opinion from you regarding the expanding tube pattern for high overload capacity. For instance, you have a certain volumetric area for gas passage at rating. In putting in an installation for 300 per cent. rating, it is natural to suppose that you should expand your tube pattern.

DR. JACOBUS: This is a feature of boiler design that is a difficult one to analyze. Two elements must be considered in determining the heat-absorbing capacity of a boiler. One is the effect of radiant heat and the other the heat absorbed by conduction. Many do not appreciate the importance of considering these two elements apart from each other. About one-third of the total heat absorbed by the boiler in many cases comes from the heat radiated directly from the fire and the hot walls of the furnace. The tube spacing as well as the arrangement of baffles affects the absorption of heat by conduction. In general, increasing the area for the flow of the gases in order to reduce the draft resistance of the gases passing through the boiler lessens the rate of heat absorption, which in turn will result in higher flue-gas temperatures. When we consider the problem of securing a minimum draft drop with a maximum rate of heat absorption we enter a most difficult field. On considering the furnace side of the question, a most essential feature is that enough tube surface be exposed to the radiant heat to keep the temperature of the furnace down to a point where the brickwork can be maintained. When it comes to saying what draft resistance is the best, taking into consideration the fact that an increase in the rate of heat transmission usually results in an increase in the draft resistance, an intelligent answer can be given only by making a study of the particular installation. In our waste-heat boilers we usually have a higher draft resistance than in direct-fired boilers and employ an induced-draft fan. In these boilers we place the cross-baffles at approximately even distances apart, and for the special conditions that are involved in these boilers we thereby obtain a maximum rate of heat transfer with a minimum draft resistance.

Prescriptive Right to Flood Lands

Where right to flood lands above a dam has been acquired through long-continued exercise, the extent of flowage rights is to be measured by the height at which the waters of the stream have been set back rather than by the height of the dam. The latter measure is indicative but not conclusive, since on account of leaky condition of the dam as continuously maintained, the level of water impounded may not be as high as if the structure were tight. (Michigan Supreme Court, Potter vs. Dundee Hydraulic Power Co., 165 Northwestern Reporter, 689.)

The Storage of Bituminous Coal*

By John H. Anderson

Owing to various reasons, probably more coal is held in reserve at the various works throughout the country at the present time than there ever has been before, yet in many cases precautions are not taken to prevent loss either by deterioration or even by fire.

The writer has been called to examine heaps of coal that were on fire, and the results of these examinations have supported the practice embraced in the following lines. On carrying out the suggestions given, no further trouble was experienced. Although these notes are based on a pile of 16,000 tons, this quantity is a very small portion of the tonnage deposited, from which the general experience was gained. Some of the heaps have been deposited over three years. This pile was selected as an example, due to its being all small coal, consisting of several kinds—washed and otherwise—some of a supposedly dangerous kind for storing, containing a lot of very fine smalls. All the material was of a bituminous nature, fairly high in volatile matter, and the whole was stored in the open; therefore it had to undergo all effects due to atmospheric conditions. As the storing of the coal was considered a temporary measure, very little preparation was done to the site, which was on marsh ground in its original state of alluvium deposit. The depth of the heap was increased here and there for experimental purposes, and owing to the difficulty of securing the particular coal one would desire to store, we made this heap up with various kinds which one would scarcely store under ordinary circumstances. Under these conditions extra carefulness was exercised. Temperature readings were taken at 14 different places nearly every day, at the same depth from the surface, and we occasionally took readings at the vent pipes, of which there were fifty in this heap. To find the hottest part of the heap, whenever there was anything doubtful, we took readings at every foot, from top to bottom, at certain places. The maximum and minimum temperature of the atmosphere and the kind of weather were also recorded.

Warmest Place in Pile

From previous experience we found the warmest place to be between 6 and 8 ft. deep from the surface, so from this we established a depth of 7 ft. as the standard depth to record temperature. Occasional check readings and all warm places (taken at very foot) were observed in addition. Generally speaking, I found the readings taken were very trustworthy; the men took great interest in the work. The temperature tubes were ¾-in. or 1-in. gas tubing, and driven from the top to the bottom of the coal. They should be long enough to project 2 or 3 ft. above the coal, and each tube had a numbered metallic label so that it could easily be recognized.

Regarding vent pipes, in most cases these were old scrap tubes about 8 ft. long and 3 to 4 in. in diameter. Four holes were punched in the pipes about every 8 in. or so, stabbed from the outside with a square-tapered punch to about ¾ in., thus leaving a burr, which prevented the coal from going down inside the tubes. To facilitate the driving into the coal, the ends of the tubes were flattened, chisel shape, just leaving an aperture of about ½ in., thus preventing the accumulation of water, and allowing for further venting area. The vent pipes were driven down to the 7-ft. mark, leaving about a foot projecting above the coal. On this a distinctive number was painted, to which temperature readings were credited similar to the temperature pipes.

The plan of the heap is a triangular-shaped figure with a surface area of about 46,000 sq.ft., with an average depth of 13½ ft. and a maximum depth of 16 ft. The actual pile consists of North Country, Scotch and Yorkshire coals.

Although it would be best to deposit coal during cool, dry weather, no choice could be taken. Some coal was deposited during very hot weather, while other was deposited in heavy rain; again, some of the material was quite dry when discharged from the steamer, while other was as wet as it possibly could be, due to the drainage to the bottom of the hold during the transport of washed coal.

Bearing these conditions in mind, and also that the heap is in the open, one gets as near as possible to the maximum difficulties one could expect as regards the liability to create spontaneous ignition and general depreciation of the heating value of the fuel when finally consumed in the furnace, that is, if care is not observed in the treatment of the pile during storage.

It is generally well known that coal is in a state of combustion at all temperatures, due to its absorption of oxygen from the atmosphere. When the coal is at a low temperature this oxygen absorption is very little, therefore there is not much heat generated. On the other hand, heaps may be composed of small coal, which may be so dense that there will not be sufficient paths for the generated heat to escape; the consequence is that this heat gathers, thereby increasing the temperature of the coal, and incidentally, due to the increase of heat, it increases the rapidity and capacity for further oxygen absorption in a given time, thus giving off more heat in a given time than when the heap was cooler.

Comparing Readings

By taking periodical readings and comparing them with previous readings, one gets ample warning to prevent a fire. We made 90 deg. F. a warning temperature. When this reading was obtained at any place four further temperature pipes were driven down north, south, east and west about 10 ft. from the warm pipe. The next day the readings of these four pipes were carefully noted. The highest one would then be made the center, and further pipes would be put down in this direction. The idea is to locate the source of heating, which may be communicating only a portion of its heat to the standard temperature tube. When this warmest place was found an additional vent pipe would be put in there, which generally arrested the rise of heat. We would then pull out the smaller temperature tubes. We made 100 deg. F. a danger reading—that is, if the insertion of a vent pipe failed to arrest the rise of temperature—but let it reach 100 deg. F., we gave orders for a trench to be dug, one foot deep on every occasion. Thus if the daily readings were at 100 deg. F., say, for three days, then this spot would be found trenched three feet deep. Originally this danger temperature was 95 deg. F., and on four occasions we trenched at one place. This was the only trenching done in the heap—about 10 tons of material removed in all. At no time did the readings of this pile reach 100 deg. F.; probably the trenching on this occasion would have been unnecessary if additional vent pipes had been inserted. However, this was the hottest part of the pile throughout the whole period. This part was in the neighborhood where the coal was deposited to a depth of 16 ft.

Handling Makes Difference

The handling of the coal so many times makes a great difference in appearance when it arrives at its destination, and with some of the more friable coal quite a large percentage of smalls are made from the coal, which was all screened pieces at the colliery. The liability of this small coal to create spontaneous combustion is very pronounced, both from its size and also from it closing up the path whereby the heat generated would otherwise escape freely to the atmosphere. This will be better understood by considering the greatly increased area of coal that is exposed when a lump is broken up, producing more surface to absorb oxygen.

There is one safe height that must not be exceeded, but as there are other factors to be taken into consideration, it will almost be impossible to fix this safe height for every heap. The height of pile can be increased providing means are taken to vent it; the more it is vented the higher the heap can be piled. Generally speaking, 12 to 14 ft. is about as much as one should deposit of small graded coals, and from 9 to 12 ft. for unwashed mixed coals. For slacks it depends a great deal on the composition of same. Two heaps of this material we allowed to rise up to 120 deg. F. before moving it. These heaps gave considerable trouble

*Abstract of paper read before the Institute of Marine Engineers

at the height of 10 ft. Eventually we reduced this height to 6 ft., when even then its tendency was to increase in temperature. My opinion of the cause of trouble was bad washing of the material; thus after a shower of rain the shalelike material formed a sort of plastic mass with the coal, practically preventing any escape of the heat. Heavy clouds of vapor rose from this when it was grabbed. As a rule little trouble is experienced with the storage of large coal, but in the event of a fire great difficulty will be experienced in putting it out owing to the ready access of oxygen for supporting combustion. Care should be taken not to make any smalls when depositing this coal, and if possible the coal should be selected that will weather best, otherwise that on the top will crumble up and fill up the interstices underneath.

The sun, rain and frost play a very important part in disintegration. I have split many a piece of coal that was exposed to the sun for some time by simply pouring a glass of water on the lump. Again, the brassy streaks of pyrites decompose, resulting in their swelling and causing a certain amount of breakage of the piece. Personally, I am inclined to believe that they play a very important part in the storage of coal, particularly in conjunction with rainy weather, thus being an incentive to set the pile in active oxidation.

I had rather an anxious time for some weeks with several heaps, due to the rain during last summer. Up to this time all our heaps were in a perfect state of balance regarding the escape of heat as it was being generated, but soon after many of the readings began to rise. Vapor rose quite freely out of the vent pipes, and continued to do so for several weeks afterward. Several additional vents were inserted, and we trenched at one place where the highest readings were obtained. On close examination during trenching we found that active oxidation of the pyrites had taken place, and that quite a layer of fine pyrite shale had formed, thus practically sealing the coal underneath. This material, I suggest, is from the weathered, disintegrated coal from the top, which probably had been washed down with the rain; as it further oxidized it would swell and close up still more.

Geological Age a Guide

Regarding the nature of coal and its liability to heat, generally speaking, I find that the geological age is a fair guide, the anthracites being the safest to store and the lignites the most dangerous. A good guide is the weathering effect on a sample rather prominently exposed and occasionally moistened with water by hand, that which readily crumbles up being the most dangerous. But, of course, a great deal depends on the composition of the coal, considering the impurities and foreign material that may be mixed with it.

Anything that ignites at a lower temperature than the fuel should be kept out of the heap. In case of fire, although plenty of water should be available to quench a fire if flames were seen issuing, it is better to dig all around the fire, and remove the hot coals from the heap.

If it were possible to get the water to the fire, quite a lot of it would get heated; it would gravitate to the bottom of the heap, and there spread out. This heated water may then just be sufficient to set the whole heap into active oxidation. Again, some of the steam formed may be decomposed and assist the formation of a flaming gas. I certainly should not flood a burning heap of coal except when there was an actual fire that could not be treated otherwise. As a rule, the greatest danger is up to about three months from the time of taking the coal from the pit.

It must be clearly understood that the term "vent pipes" used in this paper does not mean ventilating pipes; but that they are used purely and simply as escape pipes for the hotter gases in the heap.

The losses in calorific value of a fuel are exceedingly small, particularly if stored in a method reducing the exposed area to the atmosphere. The losses are the surface weathering, plus that given off as heat from oxidation. If the heaps are kept cool, this latter item can be neglected; as regards the former, this could be overcome by covering. But this would be rather costly for large heaps; it can be minimized by choice of coal. These losses are more apparent than real. There is a further loss, but this is mostly lost shortly after the coal is mined, in a gaseous form, and it can be neglected so far as storage is concerned.

Generally speaking, the elements lost in storing are those which in most cases are thrown away by imperfect combustion in the furnace, and I believe if the stoking of stored coal was given more consideration, practically the same results would be obtained, from an evaporative point of view, as from ordinary coals.

An allowance must be made for interest on capital cost of stock, rent of space occupied, together with expenses of handling, and, of course, insurance of the whole. This latter item is quite nominal providing systematic methods of storing are employed, as suggested in this paper.—*Electrical Review.*

Coal Conservation in the Boiler Room*

By Robert H. Kuss

In the United States the total bituminous coal production during 1917 was close to 542,000,000 tons and 90,000,000 tons of anthracite was marketed. The uses to which the bituminous coal were put have been estimated as follows: Stationary steam plants, 215,000,000 tons (40 per cent.); railway locomotives, 190,000,000 tons (35 per cent.); households, 135,000,000 tons (25 per cent.); total, 540,000,000 tons. Of the 90,000,000 tons of anthracite 40 per cent. was consumed by locomotives and 60 per cent. by mostly domestic users. Reference to the figures given shows that 60 per cent. of the total production of bituminous coal in the United States during 1917 was applied to nonproductive uses—35 per cent. for steam locomotives and 25 per cent. for domestic use.

While it is not possible to fix a definite figure or even range representing efficiency for the respective groups of manufacturing, locomotives, and domestic use, it is worth while to look into this phase of the matter. The speaker's estimates appear in Table I. They have to do with the performances of the several groups applied to a year's period, all losses being charged. It will be noticed that the steam railway locomotives are rated in a fairly high position. They do not have the wide range of practice attributed to the others, and there is a larger percentage of best practice applying to railway work than to the stationary field. Add to this the fact that the stationary fuel users not only have been using, but will continue to use, an increasing percentage of the total coal supply and it is manifest that the crux of the fuel problem so far as the conservation in its use goes, must lie within the group of fuel users who produce steam as an incident to the conduct of their other activities.

TABLE I. ESTIMATED EFFICIENCIES WHEN USING BITUMINOUS COAL

	Stationary Plants			
	High-Pressure	Low-Pressure	Railway Locomotives	Domestic
	Per Cent.			
Poor practice	50	40	60	30
Fair practice	64	56	66	40
Good practice	72–74	62	70	50
Available practice	76	68	72	55
Available increase	12	14	9	15
Available savings, tons	25,800,000		17,100,000	20,250,000
Total tonnage saving on 1917 basis			63,150,000	

The figures in Table II applied to the fuel consumption given in Table I show that there would be released for other uses a total of 63,150,000 tons of coal.

The part that air plays in furnace and boiler performance is of the greatest importance. In the writer's opinion boiler and furnace efficiency are closely related to the manner in which draft facilities are provided and utilized. In connection with draft there are the following points to bear in mind:

1. The draft capacity and intensity should be such that momentary great steam demands may be met or temporary faults of fuel-bed construction overcome.

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*Abstract of paper read at a joint meeting of the Detroit Engineering Society and the Detroit Section of the American Society of Mechanical Engineers.

2. Good judgment demands that the draft apparatus (chimney or fan) shall not have its purpose partly defeated by tortuous, ill-shaped breechings or faulty passages through settings.

3. Not only must the facilities for creating air movement through the fire be adequate, but the room delivering air to the system must have provision for the introduction of the great volume of air needed for the combustion processes.

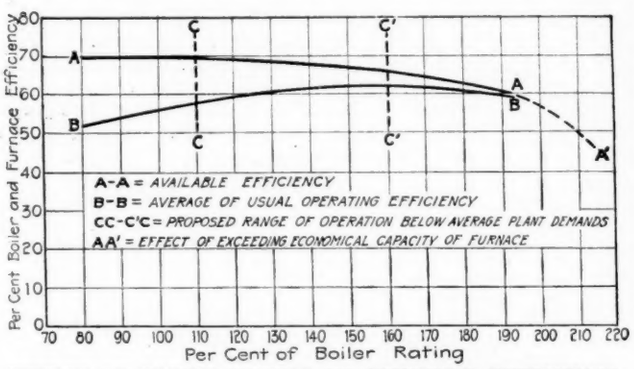
4. Any causes that tend to reduce draft intensity, as by soot deposits and air infiltration, not only bring about losses of their own accord in the boiler's functions, but tend to destroy the available elasticity of furnace operation, which is more serious still.

TABLE II. FEASIBLE GAINS IN EFFICIENCY

	Per Cent.
High-pressure steam plants	12
Low-pressure steam plants	14
Railway locomotives	9
Domestic	15

5. The rate of failure of furnace parts is inseparably tied up with the ability of the draft forces to carry away the heated gases as rapidly as evolved.

When several boilers are combined for service, there is usually a wide choice given in selecting the number to be run. Assume an ordinary plant containing eight 400-hp. boilers equipped with stokers to the fuel supplied. Suppose the draft facilities are ample and the load variation between 2500 and 2800 hp., momentarily going as high as 3000 boiler horsepower. By ample draft is meant sufficient to burn, without serious furnace injury, enough coal on each grate to generate 760 hp., or 90 per cent. overload, when forced. The ordinary way to run the plant would be to place six


Per Cent Boiler and Furnace Efficiency
Per Cent of Boiler Rating
A-A = AVAILABLE EFFICIENCY
B-B = AVERAGE OF USUAL OPERATING EFFICIENCY
CC-C'C = PROPOSED RANGE OF OPERATION BELOW AVERAGE PLANT DEMANDS
AA' = EFFECT OF EXCEEDING ECONOMICAL CAPACITY OF FURNACE

EFFECT OF BOILER RATING ON COMBINED EFFICIENCY

or seven boilers in service, keeping two or one down for general cleaning and meeting load changes by varying all the deliveries as by altering damper positions, grate speeds, etc. No doubt the resulting steam generation might easily be satisfactory as to pressure and quantity. The boiler, however, would be delivering a lazy performance for the most part.

To see what would happen to one of these boiler units refer to the accompanying diagram. The line *AA* represents what may be termed the maximum combined efficiency over the range for various operating rates. The mere fact that the possibility exists to attain these efficiencies at the different ratings does not assure their attainment. The lower the rate of operation the greater the opportunity for improper draft adjustment, poor fuel beds, uncleanliness and air leakage to go on unchecked and uncorrected. The effect is to obtain on the average a performance somewhat as represented by the efficiency curve *BB*. This has the characteristic of rising to a maximum height between 150 and 160 per cent. of boiler rating. In other words, slipshod methods are not as permissible if the boiler is to deliver the quantity of steam of the higher ratings. The conclusion is that it is best to run the boiler at around 150 to 160 per cent. for normal loads.

Applying this judgment to the problem, take 2650 b.hp. as the mean point of service demanded and divide by 640, the latter figure being the product of 400 and 1.60. Thus four boilers will ordinarily carry the load if means are taken to operate the units at the rating established. How shall the momentary loads beyond be handled? By bringing one unit (already in service) at a time up to its maximum capacity as the load increases up to the 3000 hp. In a like manner when the load decreases, first one unit is reduced to, say, 110 per cent. of rating, and if that reduction is not enough, a second unit is taken in hand, and so on. In other words, here is an attempt to push the operators so that they dare not neglect their duties lest they lose their grip on the steam-gage needle. When it is considered that a less number of units are being watched and less fuel is handled, the net result is favorable to the operatives. The scheme advanced has many advantages for its application, as borne out by experience. The foregoing is a mild case, and thus far only the immediate benefits in the way of economy have been stated. The corollary benefits, no less important, are less blowing down, less soot accumulation and less effort and steam for its removal, less brick maintenance per ton of coal burned, less coal loss at the closing periods of the operating day and at other slowdown periods; more time for inspection, overhauling, cleaning and repairs, and less percentage loss due to unavoidable losses such as radiation.

The ability to apply this system to its logical and best conclusion depends upon whether the available draft is adequate. If deficient, thus not permitting the attainment of a curve such as *AA*, then the opportunity for effecting the larger efficiencies is excluded, but the principle is still applicable. If the furnace capacity is inadequate, thereby causing its efficiency to fall rapidly at the higher rate, then the limits through which the scheme can be successfully applied are correspondingly reduced. If the plant is hand-fired (or even stoker-fired) and has a less number of units than that mentioned in the problem, perhaps the exclusion of one whole unit may be impracticable; in that case each grate size should be reduced. Naturally, it is extremely important to know just what the possible performance of each boiler unit may be throughout its range of working; also what is expected of the plant as a whole in the way of steam demands.

Every boiler setting should have a draft gage or draft-gage system capable of instant or constant indication of boiler uptake and furnace drafts. Accurate water-measuring and coal-weighing apparatus are needed. Each chief engineer should also possess a standard orsat or gas-analyzing set and temperature-indicating pyrometer. But having such, their use must be consistently regular with the records of observations preserved. It is useless to provide any instrument requiring the skill of a graduate chemist to keep it going unless there is a chemist on the job. Aside from all this there is no excuse for the chief engineer who possesses the facilities for regular observation and checking but fails to use them either by recording the indications or failing to study them in connection with records of water evaporated and coal burned for the purpose.

Potomac Plant to Increase Output

According to a news item, the Potomac Electric Light and Power Co. is making strenuous efforts to keep pace with demand for electric current for light and power, not only for the immediate future but far into 1919, when the urgency of service demands will be greatly increased.

With part of the proceeds of the $2,100,000 bonds recently authorized by the capital issues committee and the Public Utilities Commission the corporation has purchased and will shortly have in operation a new 15,000-kw. unit. Its capabilities for production will be fully absorbed immediately it is in operation.

Diplomacy and pleading were both necessary to get this machinery. The Navy Department first insisted that the completed turbine engine was needed by the department for a new battleship. It yielded to the plea of the officials that Washington and its activities needed the service.

The War Department then laid claim to it for use at a nitrate plant at Memphis.

By pressing the needs of Camp Humphreys, Camp Meade, Camp Meigs, the Arlington wireless towers and the various

street railways served by the corporation this demand was also dodged.

The big turbine now awaits installation. It will cost in position about $800,000.

Officials of the electric light and power corporation now admit that this big unit will not give the needed service into 1919. For that reason an order has been placed for a 20,000-kw. unit, which will be installed next year, to cost $1,000,000.

The 1918 increase in power had been planned so that in the event of any one of the units in service giving out there would be no cause for worry. The 1919 extension is expected to give the company a surplus power of considerable proportions, but with the increased demands further extensions and additions in the not distant future seem likely.

In addition to the nearby military and naval camps and the wireless, which are served by the Potomac Electric Light and Power Co., the company also supplies all the current needed for the Washington, Baltimore and Annapolis Railroad Co., the Washington-Virginia Railway Co. and the various lines of the Washington Railway and Electric Co.

A Large Turbo-Generator

A turbo-generator that is being made by the A. E. G. for the Rhein-Westfalen Electric Power Co. has an output of 55,000 kw. at 1000 r.p.m., and at 7000 volts, three-phase, with 220-volt excitation. The steam pressure is about 160 lb., the superheat 325 deg. C., and the temperature of the cooling water 27 deg. C. The whole turbine is contained in a single cylinder, and the generator is mounted on a single base. The weight of the turbine is 250 tons, the rotor alone weighing 49 tons. The generator weighs 225 tons, and its rotor 106 tons. The turbine has ten wheels, of 3.4 (11.15 ft.) and 3.8 (12.47 ft.) meters in diameter, and is fitted with blades that are free from nickel. A condenser with 3000 square meters (32,292 sq.ft.) of cooling surface takes the steam from the turbine through two outlets each of 2.4 meters (7.87 ft.) diameter.

Owing to its great length, 9 meters (29.53 ft.), it was found impossible to construct the rotor of the generator in one piece, and it had to be built up of disks keyed to the shaft. Its internal diameter is 2.2 meters (7.22 ft.), and it has been run for test purposes up to 1500 r.p.m., while some of the disks have been run up to 2400 r.p.m. The complete revolving parts are carried on three bearings, 600 millimeters (23.62 in.) in diameter. Of these, the middle bearing, which contains the solid flanged coupling, is anchored, and provision is made for the free expansion of the steam end. The complete machine is to be set on a heavy foundation of armored concrete.—*The Engineer.*

Will Not Increase Light and Power Rates

Valley City, N. D., with a municipally owned electric-light plant, will make no increase in its rates either to power or to household consumers, according to I. J. Moe, mayor of Valley City.

The municipal rate is 5 to 8c. for electricity for power purposes, and 10c. for electricity for household purposes.

Within a short time, the Valley City plant will take on the lighting of the towns of Sanborn, Rogers, Dazey and Leal, selling power to the Sheyenne Valley Electricity & Power Co., which company has established a circuit of nearly 35 miles to supply the four towns. Another source of increased revenue that will be opened by the municipal plant within a year will be a central heating system, the necessary changes in the plant proper having been made, only the laying of the mains remaining, and that work will probably be undertaken early next spring, in the event that the Federal Reserve Bank committee gives its approval to the expenditure.

With the establishment of the steam-heating system there will be utilized about $15,000 worth of heating power that now is wasted, and it is expected to carry the power and heating load with little or no additional fuel.

The plant is successfully operated with lignite coal. Heretofore, the fuel has cost about $2.75 a ton, laid down in Valley City, but this year it will cost $2 at the mine, with freight charges added, making the total cost about $3.40 to $3.50 a ton, as the coal freight rate has been advanced from about 94c. to $1.04 a ton, to $1.40 to $1.60 a ton. There is some prospect of a slight reduction in the new rate, as the state railroad commission contends the railroads have made too great an increase in their rates on lignite.

Three or four cars of eastern coal are kept on hand in case of emergency, but North Dakota fuel gives far better results. The lignite has been in use for many years past.

Development of Lignite Mining in Greek Macedonia

The absence of coal deposits has been a great handicap in the manufacturing industry of Greece, as the fuel for other than domestic purposes has had to be imported. An inferior quality of lignite has in recent years been mined in the island of Euboea and to some extent on the mainland of Greece. Consequently, the discovery of large deposits of lignite of a superior quality, which burns well alone without an offensive odor, has excited much interest.

These deposits are located about 6.21 miles north of Ekaterina and across the head of the Gulf of Saloniki from the city of Saloniki. Competent engineers have traced up to the present time a mass of approximately 700,000 tons, and the investigations have covered only a small area. It is reported that the whole region bears promise of further large deposits. The region was apparently in early geological periods a vast lake, and the lignite is evidently the result of masses of decaying water vegetation rather than of ancient forests. Three veins, each varying from 12 to 18 in. in thickness, have so far been uncovered.

Mining operations have not been greatly developed as yet, but five horizontal galleries of varying lengths have so far been driven into the mountain side. Only 20 to 25 tons per day are being extracted at present, but the engineers estimate that, as soon as transportation facilities are arranged, the output will reach 200 tons per day. There are at present about 100 men employed. A railway spur is being built to the mine from the main line of railroad running from Saloniki south to Ekaterina, Larissa, and Athens, which will soon enable the fuel to be transported to all points on this line. The mining company is a private one, controlled by Greek subjects, the principal stockholders residing at Saloniki. At the end of the war Greece will probably find this a new and most valuable asset, one which will tend to greatly stimulate manufacturing of all kinds.

At a conference with Fuel Administrator Garfield, Bernard M. Baruch, chairman of the War Industries Board, stated that the needs of war industries are growing at such a rate that only increased production of coal and steel can meet the situation. There is a particular shortage of by-products in steel plants, one mill reporting a falling off in production of 40,000 tons a month. As a new method of conserving coal and to relieve pressure on the eastern supply, the fuel administration is sending Pacific Coast coal to South American countries.

Defective mining methods have resulted in a loss varying from 50 to 150 per cent. of the coal production, says R. H. Fernald in the *General Electric Review*. Our general procedure has resulted in the flooding and caving in of mines from which only the better grades of coal have been taken, and the breaking up of the seams, thus making the removal of the coal by future generations not only expensive but so dangerous as to be prohibitive. Frequently 40 or more per cent. of the coal in a given mine could never reach the market. Even if only one-half ton of coal is lost for each ton marketed, which is common mining practice today, this wastage for the year 1917 would amount to over 300,000,000 tons.

Personals

L. R. Boyer, formerly connected with the Bureau of Standards, has joined the organization of E. & T. Fairbanks & Co., St. Johnsbury, Vt.

David Larkin, formerly chief engineer of the Fifth Avenue building, New York City, is now chief mechanical engineer with the Monsanto Chemical Co., St. Louis, Mo.

J. N. Mahoney, who has been a member of the engineering department of the Westinghouse Electric and Manufacturing Co. for the last 12 years, has resigned to open consulting offices in New York City.

Alan C. Dodson, of Bethlehem, Penn., has been appointed a member of a new committee recently formed by the Fuel Administration to aid in an intensive campaign to provide for an increased production of coal.

Halford Erickson, formerly chairman of the Wisconsin Corporation Commission, and recently of the firm of Hagenah & Erickson, Chicago, has been elected vice-president of the Louisville Gas & Electric Co., Louisville, Ky.

C. J. Peterson, who has been connected with the Stillwater, Minn., division of the Northern States Power Co. for eight years as hydro-electric superintendent, has been appointed general superintendent, succeeding C. J. Clarey.

E. P. Dilion, who has been connected with the Westinghouse Electric and Manufacturing Co. for the last nine years in various capacities and for the last year as manager of the power division at the company's New York office, has resigned to become general manager of the Research Corporation of New York.

John E. Williams has resigned as state fuel administrator of Illinois. He is succeeded by Raymond E. Durham, who has been serving as fuel administrator of Cook County (Chicago). Mr. Durham is vice-president of the Chicago Savings Bank and Trust Co. and is a well known and influential business man of Chicago.

John A. Kerley, past national president of the N. A. S. E., and who for the past twenty-one years has served as chief engineer, vice president and general manager of the City Ice Delivery Co., of Cincinnati, O., has taken service with the Dearborn Chemical Co. Mr. Kerley will be located at the Cincinnati office and will cover a portion of the state of Ohio.

C. E. Drayer has been elected secretary of the American Association of Engineers, with headquarters at 29 So. La Salle St., Chicago. Mr. Drayer was formerly secretary of the Cleveland Engineering Society and a member of its board of directors. He also organized and is secretary of the Ohio Association of Technical Societies, and is a well-known engineering author.

Dan Delaney—Following the recent announcement that John A. Kerley had associated himself with the Dearborn Chemical Co., to be located at the Cincinnati office, numerous inquiries were made regarding Dan Delaney. The company states that Mr. Delaney is not in any way affected by Mr. Kerley's appointment. He will remain manager of the Cincinnati district.

Charles O'Neill, of Altoona, Penn., has been appointed manager of the Central Pennsylvania coal district by the Fuel Administration. Mr. O'Neill will have supervision over Westmoreland, Cambria, Armstrong, Huntingdon, Somerset, Elk, Tioga, Clinton, Jefferson, Indiana, Clearfield, Cameron, Bedford, Lycoming, Blair and Centre Counties. Mr. O'Neill is secretary of the Central Pennsylvania Coal Producers' Association.

W. C. Rott, having been associated with Julian Kennedy, has resigned from his position as chief engineer to enter the employ of Arthur G. McKee & Company as office engineer. Mr. Rott was graduated from the Massachusetts Institute of Technology in 1903. His first position was in the Operating Department of the Illinois Steel Co. at the South Works. In 1904 he entered the employ, in the engineering department, of the Lackawanna Steel Co. of Buffalo, where he remained until he became associated with Mr. Kennedy as office and outside engineer. He was appointed chief engineer in 1913, which position he has held until the present time.

Engineering Affairs

The National Association of Master Steam and Hot Water Fitters has had its name changed and will be known hereafter as the Heating and Piping Contractors' National Association, Inc.

The Association of Iron and Steel Electrical Engineers will hold its 12th annual convention at the Southern Hotel, Baltimore, Md., Sept. 9-14. The following is a tentative program of the papers to be presented: Papers by the Standardization, the Safety, the Electrical Development and the Educational Committees of the Association; "Remote Controlled Sub-Station," by W. T. Snyder; "Automatic Engine Stops," by Walter Greenwood; "Standardization of the Rating of Large Steel Mill Motors," by K. A. Pauly; "Practical Method of Selecting Carbon Brushes," by Arthur Mullhaupt, Jr.; "Bridge Motors for Cranes," by R. H. McLain; "Condensers and Condensing Engineering Practice," by D. D. Pendleton; "Roller Bearings for Cranes," by P. B. Liebermann; "Installation and Operation of Auxiliary Drives," by J. D. Wright; "High-Tension Installations under Severe Conditions," by Jas. Farrington; "Electrical Driven Mills, Showing Tonnages, Costs, etc.," by J. T. Sturtevant; "60-Cycle vs. 25-Cycle for Steel Mills," by J. E. Fries.

The Administrative Engineer's Office of the United States Fuel Administration for Illinois is rapidly becoming organized under Mr. Joseph Harrington, who has recently been appointed to this position.

Questionnaires are being sent to power plants throughout the State, and arrangements are being made for their grading when returned to headquarters. Many engineers are offering their services for this work. It is the purpose to concentrate at first on cities of 15,000 population and have local volunteer committees to supervise the work in the various cities. Boiler insurance companies are coöperating cordially with the office, arranging for the checking up of questionnaires in plants visited by their inspectors.

It has been arranged to have a fuel-conservation booth at the Springfield State Fair, with a complete display of patriotic posters, an educational lantern-side exhibit, printed matter, etc. A representative will be in constant attendance at the booth to answer questions and spread information.

Miscellaneous News

A Boiler Exploded recently at a sawmill belonging to Creary Bros. in a remote section of Henderson County, Tenn., instantly killing two persons and injuring several others, one of whom died next day in the hospital. The cause of the explosion is unknown.

Work is progressing rapidly on the installation of the two new 1250-kw. engines at the Hutchinson, W. Va., power plant of the Monongahela Valley Traction Co., which, when completed, will mean a 25 per cent. increase in the capacity of the plant, and make a total of ten engines in operation there. Considerable trouble has been experienced at the Hutchinson plant of late, due to overwork caused by the shutdown of the Hayenne plant as a result of the poor water supply in Fairmont.

A Low-Pressure Corrugated copper turbine expansion joint manufactured by the Alberger Pump and Condenser Co. has an inside measurement of 7 ft. 3 in. by 5 ft., a total pipe area of nearly 31 sq.ft. This expansion joint for use between the turbine exhauster flange and the condenser inlet flange is unusual both as to the large size and its irregular shape. The flanges are heavy and reinforcing bars are provided within the corrugations to prevent the joint from collapsing under the influence of the vacuum on the inside and the air pressure outside of the joint.

New Construction

Proposed Work

Conn., New Haven—The Hamden Plains Methodist Episcopal congregation will soon award the contract for the erection of a boiler house in connection with the proposed church on Dixwell Ave. and Church St. Total cost, $60,000. E. P. Stover, 1009 Dixwell Ave., Chn.

Conn., Waterville—The Chase Metal Works Co., Waterbury, will install a hot water heating system in the proposed social building.

N. Y., Auburn—The Auburn Woolen Co. is in the market for electric motors, belting, shafting, etc., for installation in the proposed 1-story, 36 x 190 ft. dye house.

N. Y., Buffalo—The Amer. Purchase Sales Co., Ellicott Sq., has had plans prepared for the erection of a boiler, pump and still house on the Erie Canal. Estimated cost, $10,000.

N. Y., Syracuse—H. D. Phoenix, Arch., Union Block, is receiving bids for a 2-story, 100 x 200 ft. hospital to be erected at 400 West Onondaga St. for T. L. Deavor, 803 East Genesee St. A steam heating plant will also be installed. Total cost, $50,000.

N. J., Trenton—The Board of Freeholders, Mercer Co., will receive bids until Aug. 27, for furnishing 2 electric motors with gearing controls and 1 set of motors and equipment for turning Southard and Olden St. bridges. Estimated cost, $3200.

Penn., Philadelphia—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will soon award the contract for the installation of boilers and super heaters in the Navy Yard here. Estimated cost, $206,000.

Penn., Philadelphia—The Philadelphia Electric Co., 10th and Chestnut St., plans to build a generating plant on the Delaware River front, for Government use. Estimated cost, $10,000,000. W. L. Eglin, Engr.

Va., Norfolk—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will soon award the contract for the installation of boilers and super heaters. Estimated cost, $96,000. Noted Aug. 13.

Ohio, Cleveland—The Reliance Electric Co., Ivanhoe Rd., will install a steam heating system in the proposed 1-story, 50 x 162 ft. factory. Total cost, $25,000.

Ohio, Cleveland—The Torbenson Axle Co., 1115 East 152nd St., will install a steam heating system in the proposed 5-story, 75 x 300 ft. factory. Total cost, $200,000.

Ohio, Toledo—The Maternity and Children's Hospital will install a steam heating system in the proposed 3-story, 45 x 122 ft. hospital to be erected on Summit St. Total cost, $100,000. G. B. Rheinfrank, 601 Gardner Bldg., Engr.

Ohio, Toledo—The Toledo Furnace Co., Front St., will install a steam heating system in the proposed 1- and 2-story foundry on Front St. F. Warner, 768 Hippodrome Bldg., Cleveland, Engr.

Ind., Anderson—The Remy Electric Co., Columbus Ave. and Belt Ry., will install a steam heating system in the proposed 5-story, 60 x 198 ft. administration building. Total cost, $300,000. Shenk & Williams, Arcade Bldg., Dayton, Ohio, Arch.

Ill., Rock Island—The Lighthouse Inspector, Rock Island, is in the market for furnishing and delivering 1 vertical submerged tubular boiler to lighthouse tender Dandelion, f.o.b. Keokuk, Iowa.

Ind., Anderson—City plans to install 3 boilers in its lighting plant. Ultimately, new units will be built and additional equipment installed in same. E. Burke, 15 North 9th St., Supt.

Iowa, Osceola—The Board of Education plans to install a low pressure steam heating system in its proposed 3 story, 90 x 144 ft. high school. Miller, Fullenwider and Dowling, 6 North Michigan Ave., Chicago, Engr.

Kan., Baxter Springs—The Hooker Development Co., Miami, Okla., will build a concentration plant near here and install gas engine, belts, air compressors, etc., in same. Estimated cost, $60,000. M. W. Pusher, Supt.

Kan., Greece—The Eloosa Lead and Zinc Co. is in the market for boilers, engines, air compressors, belts, etc., for installation in its proposed concentration plant to be erected near here. Estimated cost, $65,000.

Kan., Greece—The Lawyers Mining Co. is in the market for boilers, air compressors, etc., for installation in the proposed concentration plant near here. Estimated cost, $65,000. G. O. Pearson, Supt.

Neb., Palmer—City will soon receive bids for the erection of an electric lighting and water-works plant. Estimated cost, $43,625. Henningson Engineering Co., 1122 Farnam St., Omaha, Neb., Engr. Noted July 30.

N. D., Pembina—The Pembina Light and Power Co. plans to extend its transmission lines from Bathgate to Hamilton and from St. Thomas, east, to Drayton. H. R. Robowski, Mgr.

Mo., Bell Center—The Bankers Mining Co. is in the market for steam engine, boilers, air compressors, belts, etc., for installation in the proposed concentration plant. Total estimated cost, $50,000.

Mo., Duenweg—The Anamento Mining Co. is in the market for air compressors, belts, etc., in connection with the proposed concentration plant to be erected here. Estimated cost, $65,000.

Mo., Joplin—The Big Elk Mining Co. is in the market for air compressors, engine, boilers, etc., for installation in the proposed concentration plant to be erected here. Estimated cost, $65,000. L. R. Ealestor, Kansas City, Mo., Mgr.

Mo., Joplin—The Marjory Stewart Mining Co. is in the market for gas engine, air compressors, belts, etc., for installation in the proposed concentration plant. Estimated cost, $45,000. G. Playtin, Gen. Mgr.

Mo., Neosho—The Neosho Mining Co. is in the market for engine, compressors belts etc., for installation in the proposed concentration plant to be erected here. Estimated cost, $65,000.

Mo., St. Louis—The Henderson Willis Welding and Cutting Co., 2305 North 11th St., is in the market for motors for installation in the proposed factory.

Mo., Springfield—The Springfield Gas and Electric Co. is having plans prepared by Sanderson & Porter, Engr., 82 Williams St., New York City, for the erection of an electric lighting plant here.

Ark., Little Rock—C. E. Taylor, Mayor, will soon award the contract for the installation of a heating system in the proposed hospital to be known as the L. H. Roots Memorial Hospital. J. P. Almand, 1105 Boyle Bldg., Arch.

Okla., Cardin—The Healdton Mining Co. plans to build a concentration plant near here, and install air compressors, engine, belts, etc., in same. Estimated cost, $65,000.

Okla., Miami—The Lead Boy Mining Co. will remodel and enlarge its concentration plant near here. Gas engine, belts, air compressors, etc., will be installed. Estimated cost, $25,000. R. H. Elkins, Supt.

Okla., Miami—The Miami Royal Mining Co. is in the market for air compressors, conveyors, engines, boilers, etc., for installation in the proposed concentration plant to be constructed near Monarch. Estimated cost, $65,000.

Okla., Picher—The Cortez Mining Co., Miami, will build a concentration plant and install air compressors, conveyors, belts, etc., in same. Estimated cost, $65,000. W. T. Landrum, Miami, Supt.

Okla., Picher—The Hidden Treasure Co. will build a concentration plant near here and install motors for air compressors and crushers, conveyors, etc. Estimated cost, $65,000. C. S. Campbell and J. Gufford, Baxter Springs, Kan., Supt.

Okla., Quapaw—The Red Rose Mining Co. is in the market for either electric or steam crushers, belts, air compressors, etc., for installation in the proposed concentration plant near here. Estimated cost, $65,000.

Calif., Fresno—The San Joaquin Light and Power Co., H and Tulare Sts., has purchased a site on California and Orange Sts., and plans to build a power plant.

Calif., Martinez—City is in the market for 2 triplex pumps, etc., in connection with the proposed construction of a water distributing system. Total cost, about $130,000. Oldstead and Gilleden, Hollingsworth Bldg., Los Angeles, Engr.

Calif., San Diego—U. S. Government appropriated $2,000,000 for marine brigade on Dutch Flats. Work includes heating, lighting, water-works and sewerage system. Estimated cost, $600,000.

CONTRACTS AWARDED

N. Y., Buffalo—The General Electric Co., Electric Bldg., has awarded the contract for the erection of a 3-story, 80 x 278 ft. power house and factory, to Huntley & Derdenger, Electric Bldg. Estimated cost, $200,000.

N. Y., Gardenville—The Pennsylvania R. R., Broad St. Sta., Philadelphia, has awarded the contract for various units to be erected here, including a power house, machine shop, engine house, etc., to Wilson and English Constr. Co., 50 Church St., New York City. Estimated cost, $2,000,000.

N. Y., Schenectady—The Mohawk Gas Co., 511 State St., has awarded the contract for the erection of a 1-story, 50 x 90 ft. boiler house on Villa Rd., to T. M. Hanrahan, 16 Wendell Ave. Estimated cost, $35,000; cost plus percentage. Boilers, power, piping, feed water heaters, etc., will be installed in same.

N. Y., Watertown—The New York Central R.R., Grand Central Terminal, New York City, has awarded the contract for the erection of a 1-story, 110 x 350 ft. engine house here, to the Walsh Constr. Co., 114½ North 3rd St., New York City. About $200,000. Power equipment, including blowers, motors, pumps, etc., will be installed in same.

N. Y., Utica—The Utica Gas and Electric Co., 222 Genesee St., has awarded the contract for the erection of a 1-story 32 x 86 ft. sub power station on Washington St., to the Kimberly Constr. Co., Mayo Bldg. Estimated cost, $15,000; cost plus percentage basis.

N. J., Bordentown—City received low bid for furnishing and delivering 2 new motor driven centrifugal pumps with automatic control outfit for the water works system, from the W. R. Thropp Sons Co., East State St., $7000.

N. J., Newark—Mass & Waldstein, 437 Riverside Ave., have awarded the contract for the erection of a 1-story, 53 x 70 ft. boiler house for operation at the Chemical works on Ave. R and Passaic River, to H. B. Doremus and Co., 36 Orange St. Estimated cost, $50,000. Boilers and auxiliary apparatus will be installed.

N. J., Pompton Lakes—City has awarded the contract for the erection of a brick and concrete power plant near Pompton Lake Dam, to the F. Kilgus Corporation, 138 6th St., Newark. Estimated cost, $31,406. Noted Aug. 6.

Penn., Philadelphia—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for 2 electric traveling cranes, to Niles, Bement & Pond, --- Bway., New York City, $14,785 (120 days).

W. Va., Morgantown—Monongalia Co. has awarded the contract for the installation of a heating system in the proposed 3-story, 122 x 143 ft. infirmary, to E. R. Baker, Morgantown. Estimated cost, $15,000; total cost, $150,000.

Ohio, Bedford—The Board of Education, Cuyahoga, Co., has awarded the contract for the erection of a 2-story, 55 x 108 ft. school, to Clemmer & Johnston, High and Church St. A steam heating system will be installed in same. Estimated cost, $100,000.

Ohio, Canton—The Timken Roller Bearing Co. has awarded the contract for the erection of a 1-story, 75 x 100 ft., power plant, to the G. Fuller Co., Swetland Bldg., Cleveland. Estimated cost $150,000. Complete power equipment, etc., will be installed. Noted Aug. 13.

Ohio, Lakewood—The Templar Motor Co., Guardian Bldg., Cleveland, has awarded the contract for the erection of a 1-story, 60 x 600 ft. factory, to the Hunkin Conkey Co., Cuyahoga Bldg., Cleveland. A steam heating system will be installed. Estimated cost $50,000.

Ohio, Youngstown—The Market Realty Co., Front and Phelps St., has awarded the contract for the erection of a 1-story, 120 x 130 ft. market house, to C. Shutrumpt and Son, Youngstown. A steam heating system will be installed. Estimated cost, $150,000.

Ind., New Albany—The Calumet Fertilizer Co. has awarded the contract for the erection of a 1-story, 100 x 250 ft. factory, to the Austen Co., 16,112 Euclid Ave., Cleveland, Ohio. A steam heating system will be installed. Estimated cost, $60,000.

Ill., Chicago—The Board of Education received low bids for the installation of a steam heating system in the proposed garage to be erected on Robey St., from W. Sullivan Co., 34 West Austin St., $2411; H. P. Reger, 5514 Lake Park, $2600; American Plumbing and Heating Co., 189 North Clark St., $2745.

Ill., Chicago—The Board of Education received low bids installing a heating system in the Wadsworth School, from E. J. McDonough Co., 46 East Kinzie St., $32,400; P. Macey Co., Chicago, $32,450; J. R. Kehm, 8 East Austin St., $32,675. Noted Aug. 6.

Kan., Wichita—The St. Francis Hospital has awarded the contract for the erection of a 2-story, 49 x 68 ft. power house and laundry, to the H. I. Ellis Constr. Co., 927 North St. and Francis St. Estimated cost, $20,000. Noted May 21.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current
Buckwheat	$3.40
Rice	2.90
Boiler	2.65
Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual
Pea	$5.20	$5.95
Buckwheat	5.15	5.90
Rice	4.65	5.10
Barley	4.15	4.30
Boiler	4.60	....
Broken	6.75	7.50
Egg	6.35	7.10
Stove	6.60	7.35
Chestnut	6.70	7.45

Quotations for domestic coals at the upper ports are 5c. higher on account of the differenec in freight rates. Prices for buckwheat, rice, barley and boiler are not fixed by the Government.

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports are 5c. higher on account of the difference in freight rates.

The foregoing prices ar exclusive of the 3 per cent. war freight tax on both anthracite and bituminous.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The ratte to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$3.45	$3.10	$4.60	$4.00
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.80
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70		$3.25—3.40
Mine-run	2.35—2.50		3.00—3.15
Screenings	2.05—2.20		2.75—2.90

St. Louis—Prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Mt. Olive & Staunton	Standard
6-in. lump	$2.55-2.70	$2.55-2.70	$2.40@2.70
3-in. lump	2.55-2.70	2.55-2.70	2.40@2.70
Steam egg	....	....	2.40@2.70
Mine-run	2.35-2.50	2.35-2.50	1.85@2.00
No. 1 nut	2.35-2.50	2.55-2.70	....
2-in. screen	2.05-2.20	2.05-2.20	....
No. 5 washed	2.05-2.20	2.05-2.20	1.25@1.50

Williamson-Franklin rate to St. Louis is $1.10, other rates, $0.95.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam	$2.50	$2.80	$2.20
Cahaba, Black Creek, Brookwood, Blue Creek	3.30	3.45	2.80
Pratt, Jaeger, Jefferson Nickel Plate	2.70	3.00	2.40
Corona	2.75	3.10	2.40

The above are Government prices per net ton of 2000 lb. mines and include the 45c. per ton allowed by the wage agreement, less 10c. reduction which was effective May 25, as a result of the agreement with the railroad administration for furnishing fuel coal.